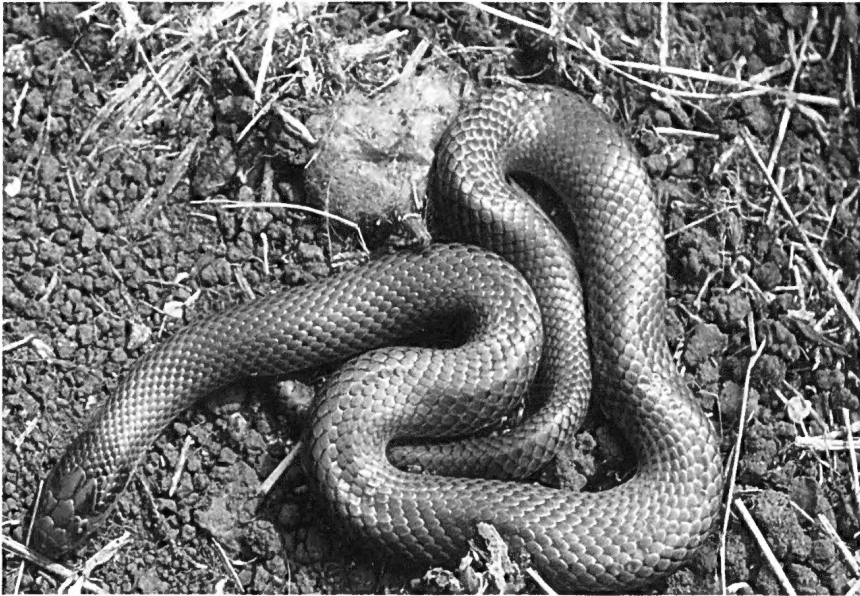


# The Victorian Naturalist



Volume 138 (2)

April 2021



*Published by The Field Naturalists Club of Victoria since 1884*

*The Victorian Naturalist*  
is published six times per year by the

**Field Naturalists Club of Victoria Inc**

Registered Office: FNCV, 1 Gardenia Street, Blackburn, Victoria 3130, Australia.  
Postal Address: FNCV, PO Box 13, Blackburn, Victoria 3130, Australia.  
Phone +61 (03) 9877 9860; email: admin@fncv.org.au  
www.fncv.org.au

Patron: The Governor of Victoria, the Honorable Linda Dessau AC

Address correspondence to:  
The Editors, *The Victorian Naturalist*, PO Box 13, Blackburn, Victoria 3130, Australia.  
Phone: (03) 9877 9860. Email: vicnat@fncv.org.au

The opinions expressed in papers and book reviews published in *The Victorian Naturalist* are those of the authors and do not necessarily represent the views of the FNCV. Copyright of all original material published in *The Victorian Naturalist* remains with the author.

**Yearly Subscription Rates – The Field Naturalists Club of Victoria Inc**

(effective from 1 July 2019)

**Membership category**

Single	\$ 86	Institutional	
Family	\$111	- within Australia	\$172
Single Country/Concession	\$ 65	- overseas	AUD186
Family Country/Concession	\$ 86		
*Junior Family	\$ 52		
Junior additional	\$ 17	Schools/Clubs	\$99
Student	\$ 39		

\* Junior membership is entitled to receive *Junior Naturalist* only.

Non-member fees: Meetings \$3; Excursions \$5

**All subscription enquiries should be sent to:**  
FNCV, PO Box 13, Blackburn, Victoria 3130, Australia  
Phone 61 3 9877 9860. Email: admin@fncv.org.au

**Corrigendum:** On page 31 of *The Victorian Naturalist* 38 (1), February 2021, the publisher of *Fungi Down Under* by Pat and Ed Grey was mistakenly given as FNCV. It was in fact published by Fungimap.

# The Victorian Naturalist



Volume 138 (2) 2021

April

Editors: Gary Presland, Maria Gibson, Sue Forster

Editorial Assistant: Virgil Hubregtse

---

<b>Research Reports</b>	An assessment of nest box occupancy and program effectiveness in a bushfire recovery program in Warrumbungle National Park, northern inland New South Wales, <i>by Jessica K Murphy and Sophia C Dunn</i> .....36
	Scale anomalies in the Little Whip Snake <i>Suta flagellum</i> (Elapidae), <i>by Grant S Turner</i> .....45
<b>Naturalist Notes</b>	Further observations of Australasian Grebe <i>Tachybaptus novaehollandiae</i> activity on two waterbodies in Clayton, Victoria, <i>by Virgil Hubregtse</i> .....53
	If this is <i>Dacryopinax spathularia</i> , look what we've been missing! <i>by Sue Forster</i> .....56
<b>Honours</b>	2020 Australian Natural History Medallion: Craig Morley, <i>by Maxwell Campbell</i> .....61
<b>Australian Natural History Medallion Trust Fund</b>	..... 64

ISSN 0042-5184

---

**Front cover:** Little Whip Snake *Suta flagellum* (Elapidae). Photo Grant S Turner.

---

# An assessment of nest box occupancy and program effectiveness in a bushfire recovery program in Warrumbungle National Park, northern inland New South Wales

Jessica K Murphy<sup>1\*</sup> and Sophia C Dunn<sup>2</sup>

<sup>1</sup>Duck Halt, Corbett Street, Darlington Point, NSW 2706;

<sup>2</sup>Honiton Avenue West, Carlingford, NSW 2118.

\*Corresponding author: <thegriffithmurphy@protonmail.com>.

## Abstract

Tree hollows are an essential resource for numerous fauna species, and their loss is a threat to hollow-dependent fauna. One solution to this problem is to install artificial hollows such as nest boxes. This study explored nest box occupancy and influencing factors in a National Parks and Wildlife Service bushfire recovery program after a bushfire in Warrumbungle National Park, New South Wales. Occupancy one year after installation was initially low, at 4% of nest boxes checked, but increased to 33% after two years (still relatively low compared to similar studies elsewhere in Australia). Occupancy was significantly correlated with nest box height and tree trunk diameter, with those nest boxes placed higher or on smaller trees more likely to be occupied. Several nest boxes became unstable or infested with European Honey Bees, potentially discouraging occupancy by native fauna. Suggested improvements to the program include monitoring a subset each year or reducing the total number of nest boxes, allowing consistent monitoring and maintenance, and monitoring in different seasons to explore variations in occupancy. (*The Victorian Naturalist* 138 (2), 2021, 36–44)

**Keywords:** artificial hollows, hollow-nesting fauna, post-fire recovery

## Introduction

Hollows in live and standing dead trees are an essential shelter and breeding resource for many Australian forest vertebrates (Gibbons and Lindenmayer 1996; Harley 2006; van der Ree *et al.* 2006; Koch *et al.* 2008). The loss of hollow-bearing trees is a threat to hollow-dependent species (Gibbons and Lindenmayer 2002; Beyer and Goldingay 2006; Goldingay 2009). Hollow loss is listed as a key threatening process in New South Wales (NSW) under the *Biodiversity Conservation Act 2016*, and as a potentially threatening process in Victoria under the *Flora and Fauna Guarantee Act 1988*. A process contributing to this loss is bushfire (NSW Scientific Committee 2007). Although moderate-intensity fire can promote hollow formation (Adkins 2006; Parnaby *et al.* 2011), hollow-bearing trees are vulnerable to destruction when flames enter the trunk via hollows (Parnaby *et al.* 2011; NSW Scientific Committee 2007). With the risk of intense bushfires predicted to increase in eastern Australia due to climate change (Lucas *et al.* 2007; Clarke *et al.* 2013), there is a need for post-fire recovery programs for the conservation of hollow-dependent species.

A common solution to hollow loss is the use of artificial hollows, usually in the form of nest boxes (Beyer and Goldingay 2006). Some studies have reported successful nest box programs with high rates of occupancy by targeted fauna, for example Gouldian Finch *Erythrura gouldiae* (Brazill-Boast *et al.* 2013), Leadbeater's Possum *Gymnobelideus leadbeateri* (Harley 2006) and Squirrel Glider *Petaurus norfolcensis* (Goldingay *et al.* 2015). Other studies reported less success: for example, low rates of occupancy in the target species Superb Parrot *Polytelis swainsonii*, Brown Treecreeper *Climacteris picumnus* and Squirrel Glider (Lindenmayer *et al.* 2017); occupancy dominated by non-target species including exotics (Le Roux *et al.* 2016); and high rates of nest box attrition (Lindenmayer *et al.* 2009). Additional challenges in nest box programs include limited nest box longevity compared to natural hollows (Lindenmayer *et al.* 2017), and installation, monitoring, and maintenance costs (Le Roux *et al.* 2016).

The selection of natural and artificial hollows by fauna is influenced by many attributes, including hollow aspect, internal volume, height, entrance size, thermal insulation and

the surrounding habitat (Durant *et al.* 2009; Goldingay and Stevens 2009; Goldingay *et al.* 2020). Preferences vary between species (Beyer and Goldingay 2006). In a nest box program, these attributes are one of the factors that can influence occupancy by target species. Ongoing monitoring of nest box occupancy can be used to determine how effective the nest box programs are in meeting the needs of target species (Lindenmayer *et al.* 2017; Goldingay *et al.* 2018).

This study investigated an established post-fire nest box program in a national park in northern inland NSW, an area where information on the outcomes of nest box programs is limited. It examined how many nest boxes were used in the first two years after installation, and analysed the influence of various nest box attributes on occupancy. Findings were used to investigate the effectiveness of the program and to develop recommendations for future management.

## Methods

### Study area

Warrumbungle National Park (NP) (23 312 ha) is located about 11 km west of Coonabarabran, northern inland NSW, in the Pilliga subregion of the Brigalow Belt South Bioregion (Office of Environment and Heritage [OEH] 2012). This study took place in open woodland and partly cleared former pasture of the central valley and lower slopes of Warrumbungle NP, an area of around 80 ha (Fig. 1). Dominant vegetation was Blakely's Red Gum *Eucalyptus blakelyi*, Yellow Box *E. melliodora*, Narrow-leaved Ironbark *E. crebra*, River Oak *Casuarina cunninghamiana*, and Rough-barked Apple *Angophora floribunda*. Around 80 hollow-dependent native fauna species have been recorded in Warrumbungle NP (OEH 2018), including the threatened Little Lorikeet *Glossopsitta pusilla*, Brown Treecreeper, Squirrel Glider, and Yellow-bellied Sheath-tail-bat *Saccolaimus flaviventris*.

In January 2013, a bushfire burned around 95% of Warrumbungle NP (NSW Coroner's Court 2015). Fire intensity was very high, with vegetation in some areas completely reduced to ash. Many hollow-bearing trees were lost, reducing the availability of shelter and nest sites for hollow-dependent species (OEH 2015), but

no data was recorded on hollow availability either before or after the fire. Many native animals were killed and foraging resources were reduced. No population monitoring was done for this study, but it is to be expected that the population of many native species was reduced.

### Nest box program

After the bushfire, a nest box program was implemented by the National Parks and Wildlife Service (NPWS) to provide additional habitat for hollow-dependent birds and mammals (OEH 2015). The authors were not involved in the design or installation of the nest boxes, and minimal information is available on the program strategy. NPWS installed 394 plywood boxes, in seven designs with different box dimensions and entrances for different fauna groups. These included Kookaburra, Large Parrot, Small Parrot, Possum, Shrike-thrush, Glider, and Microchiropteran Bat nest boxes (Fig. 2). Details of the structures of the first six types are available in Ellis (2016). Bat boxes (430×163×150 mm) were made of the same material, with the entrance at the base and strips of shade cloth inside. All nest boxes had a hinged lid to allow access.

Nest boxes were installed by NPWS between late 2013 and early 2014 at fifteen different sites (Table 1). Sites were primarily in the valley flats around the Visitor Centre. These were accessible by road, where fire intensity was lower and some vegetation remained, and close to visitor facilities as part of a community monitoring project (OEH 2015). Nest boxes were attached to trees with expandable bands to accommodate growth. The installation heights were not recorded. Surveyed nest boxes ranged from 2.4 to 7.3 m above the ground, but many were installed higher. Nest boxes were numbered and the location of each was recorded by GPS.

### Monitoring nest box occupancy

Nest box occupancy was monitored annually by NPWS for the first two years after installation: December 2014–January 2015 (Year 1), and November–December 2015 (Year 2). This program was implemented by NPWS, but the first author of this study assisted with monitoring as a volunteer. On both occasions, only some sites were visited due to time and accessibility

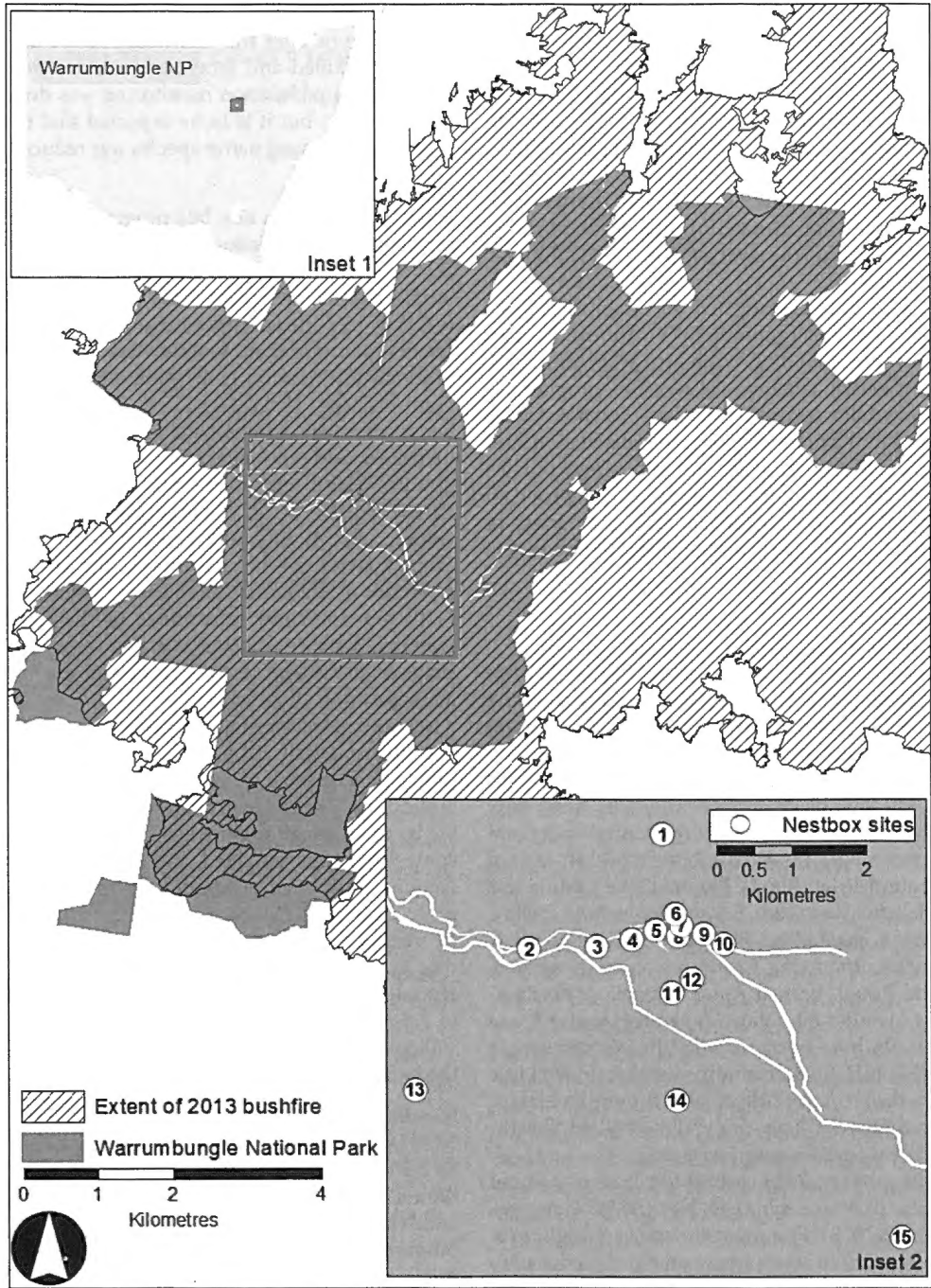


Fig. 1. Map of study area in Warrumbungle National Park. Locations of sites 7 and 8 are partly obscured behind site 6.

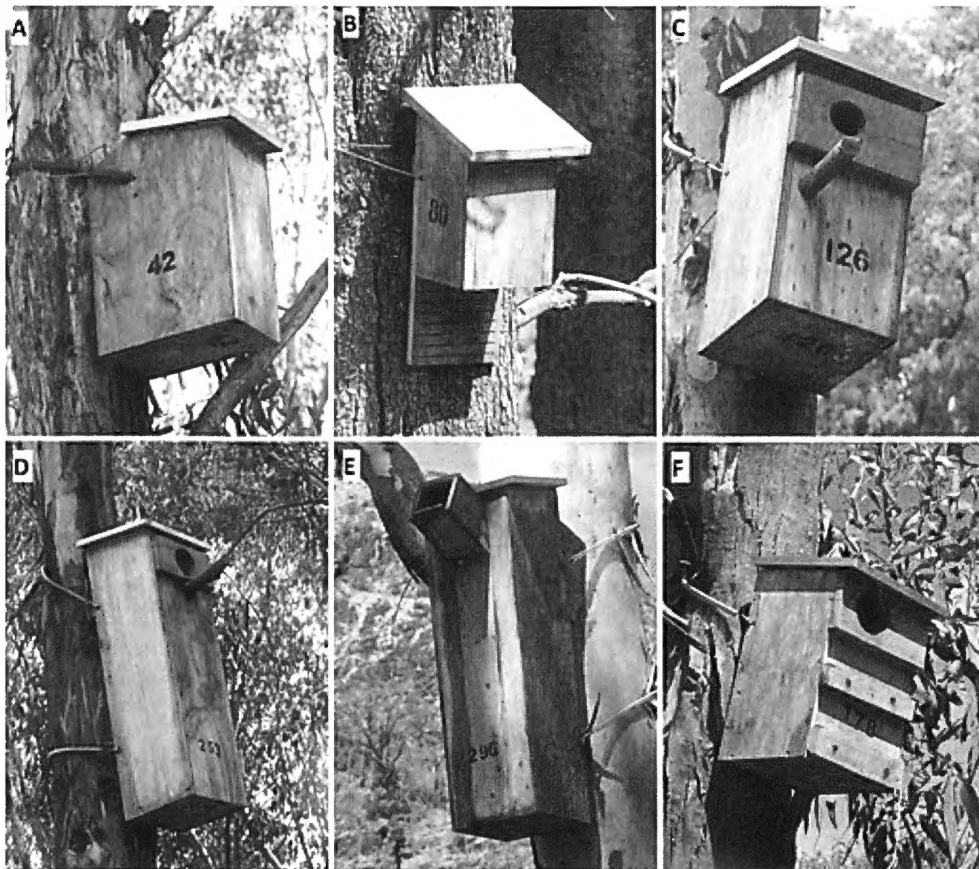


Fig. 2. Some of the different nest box types used in the Warrumbungle National Park nest box program: A) Glider; B) Bat; C) Small Parrot; D) Large Parrot with perch; E) Large Parrot with spout; F) Possum. Photos JK Murphy and MJ Murphy.

limitations, with 115 nest boxes (29%) at six sites checked in Year One and 166 (42%) at eight sites in Year Two (including the six sites from the previous year). Some nest boxes at these sites were not checked (five in Year 1 and twelve in Year 2) as they could not be located or were too high to access. The remaining seven sites were not visited during this study. Each nest box was inspected during the day by inserting a Brite Star® 90° inspection camera on a 4.5 metre pole. A nest box was deemed occupied if an animal or a nest (identifiable as a formed structure, with either fresh or dead leaves) was present. Many mammals use several hollows concurrently (Goldingay 2011), but this method indicates how many nest boxes

were used. Occupied nest boxes were photographed, and animals identified to species level where possible. The presence of invertebrates was noted where possible.

In Year 2, information on factors potentially influencing occupation was recorded at each nest box. This included tree size (diameter at breast height), stability of nest box (firmly fixed to tree, or loosely attached and moved when nudged with camera pole), height of nest box (distance above ground, measured to base of box), and distance to nearest tree (from trunk to trunk) as a basic measure of tree density. Factors recorded but not investigated in this study included tree species, nest box type, and aspect.

**Table 1.** Details of nest box sites in Warrumbungle National Park.

#	Site name	Area (ha)	No. of nest boxes	Density (boxes/ha)	Checked	
					Year 1	Year 2
1	Northern Fire Trail	8.5	44	5		
2	Wambelong	3.0	19	6		
3	Canyon	2.2	19	9	X	X
4	Nature Trail	0.9	20	22		
5	Creek	1.6	13	8		X
6	Walaay	3.2	24	8		
7	Visitor Centre Walaay	0.5	8	16		
8	Blackman 1	1.7	17	10	X	X
9	Blackman 2	2.1	24	11	X	X
10	Belouery Flats	0.8	9	11	X	X
11	Old Visitor Centre	2.9	22	8	X	X
12	Link Track	15.9	45	3		X
13	Burbie Track	25.2	58	2		
14	Pincham	6.0	43	7		
15	Strathmore	5.4	29	5	X	X

**Table 2.** Results of nest box monitoring at sites checked in Year 1.

Site	Nest boxes with animals	Nest boxes with nests	Nest boxes with nil sign of occupancy	Nest boxes not checked	Total
Belouery Flats	0	0	9	0	9
Blackman 1	0	0	15	2	17
Blackman 2	1 (unidentified glider)	1	21	1	24
Canyon	0	0	19	0	19
Old Visitor Centre	1 (unidentified glider)	0	20	1	22
Strathmore	1 (Common Ringtail Possum)	1	26	1	29
<b>Total</b>	<b>3</b>	<b>2</b>	<b>110</b>	<b>5</b>	<b>120</b>

**Table 3.** Results of nest box monitoring at sites checked in Year 2.

Site	Nest boxes with animals	Nest boxes with nests	Nest boxes with nil sign of occupancy	Nest boxes not checked	Total
Belouery Flats	1 (unidentified glider)	6	1	1	9
Blackman 1	1 (unidentified glider)	3	13	0	17
Blackman 2	0	5	15	4	24
Canyon	1 (unidentified glider)	7	11	0	19
Creek	0	4	9	0	13
Link Track	1 (unidentified glider)	17	22	5	45
Old Visitor Centre	0	4	16	2	22
Strathmore	1 (Common Ringtail Possum)	4	24	0	29
<b>Total</b>	<b>5</b>	<b>50</b>	<b>111</b>	<b>12</b>	<b>178</b>

### Statistical analysis

Monitoring data were provided to the authors by NPWS for further analysis. Year 2 data were analysed using Minitab® statistical software 17.3.1 to investigate any correlation between

nest box occupancy and influencing factors. Year 1 data were not included in this analysis. A binary logistic regression was performed to compare nest box occupancy against height, tree diameter, distance to nearest tree, and

stability. Data from the Strathmore site were excluded, as quasi-complete separation of data points was detected when they were included. A total of 137 nest boxes from seven sites was included in this analysis.

Data from Year 2 were analysed in Microsoft Excel to visualise trends identified by the regression. This involved comparing mean height of occupied versus unoccupied nest boxes, and mean diameter of trees with occupied versus unoccupied nest boxes.

## Results

In Year 1, signs of vertebrate occupancy (fauna in residence, or leaf nests) were found in five (4%) of the nest boxes checked ( $n=115$ ) (Table 2). Animals were seen in three nest boxes, including Common Ringtail Possum in one, and unidentified medium-sized gliders (either Sugar Glider *Petaurus breviceps* or Squirrel Glider) in two. Nests of green eucalypt leaves were found in the two other occupied boxes and were consistent with those made by gliders (R Goldingay, pers. comm. 25 April 2020). No evidence was seen of nest box use by birds or other vertebrates.

In Year 2, signs of vertebrate occupancy were found in a total of 55 (33%) of nest boxes checked ( $n=166$ ) from eight sites (Table 3). Animals were seen in five nest boxes, including one with Common Ringtail Possum (Fig. 3), and four with medium-sized gliders. A photo of a group of medium-sized gliders in one photo (Fig. 4) was subsequently confirmed to be Sugar Gliders (T Soderquist, pers. comm. 22 June 2017; and K Vernes, pers. comm. 20 July 2017). Gliders were recorded in Glider and Large Parrot nest boxes, while the Common Ringtail Possum was in a Small Parrot nest box. The increase from 4% occupancy in the previous year to 33% was largely due to an increase in the number of nests, which were found in 50 occupied nest boxes. Most of these nests consisted of green eucalypt leaves (indicating the presence of gliders) but eight were made of native grasses, one of bark and one of sheoak needles. Leaf nests were recorded in Glider, Possum, Small Parrot, Large Parrot, Kookaburra and Small Bird nest boxes. No evidence was seen of nest box use by birds or other vertebrates.



Fig. 3. Common Ringtail Possum photographed in nest box, Warrumbungle National Park. Photo National Parks and Wildlife Service Coonabarabran.



Fig. 4. Group of Sugar Gliders photographed in nest box, Warrumbungle National Park. Photo National Parks and Wildlife Service Coonabarabran.

The binary logistic regression analysis found that occupancy was significantly correlated with nest box height ( $p=0.001$ ,  $df=1$ ) and tree trunk diameter ( $p=0.004$ ,  $df=1$ ), but not with distance to nearest tree ( $p=0.450$ ,  $df=1$ ) or nest box stability ( $p=0.760$ ,  $df=1$ ). Data visualisation showed that the height correlation was positive while the tree trunk diameter correlation was negative, with mean height of occupied nest boxes (4.8 m) higher than unoccupied nest boxes (4.2 m), and a mean diameter of tree trunks with occupied nest boxes (1.63 m) lower than with unoccupied nest boxes (1.91 m). This suggests that nest boxes that were higher above the ground or on trees with a smaller trunk diameter were more likely to be occupied.



Fig. 5. Unstable nest box, Warrumbungle National Park. Photo MJ Murphy.

Invertebrates occupied several nest boxes in each monitoring period. These included native species such as spiders, wasps, and ants. Some nest boxes contained hives of the feral European Honey Bee *Apis mellifera*, but the number of hives was not recorded.

Some nest boxes were not securely attached (Fig. 5). The number of unstable nest boxes was not recorded in Year 1. In Year 2, 33 (20%) of those checked ( $n=166$ ) were unstable, some moving when nudged with the camera pole, and some visibly swaying in the wind. Despite this, four had signs of occupancy. Over the monitoring period, two checked nest boxes fell from their tree, one sliding to the ground and the other tipping over. Several nest boxes could not be accessed to check occupancy or stability as they were too high.

Distance to nearest tree ranged from  $<1$ –58 m. The nest box at 58 m was not occupied, but several at the higher end of this range were found to contain leaf nests.

## Discussion

### *Nest box occupancy by target and non-target species*

The 33% occupancy rate in Year 2 of this study is at the lower end of the range reported in other recent Australian studies (Lindenmayer *et al.* 2009; Goldingay *et al.* 2015; Le Roux *et al.* 2016; Lindenmayer *et al.* 2017) that reported occupancy rates of between 31% and 69%. The lower occupancy rate in Warrumbungle NP may be due, in part, to the impact of the bushfire on local wildlife populations. The occupancy rate increased eight-fold between the first

and second years of this study, demonstrating that nest box use, while initially low, can increase over time. However, a study by Lindenmayer *et al.* (2009) found that, while nest box use may increase in the first few years after placement, this may later decline as nest boxes deteriorate. Nest box longevity can range from around 20 years (Goldingay *et al.* 2018), to as little as five years (Lindenmayer *et al.* 2009). Continued monitoring of the Warrumbungle nest boxes over the next few years would determine whether the occupancy rate continues to increase, and how long nest boxes remain functional in this location.

In the present study, occupancy of nest boxes was positively correlated with nest box height above the ground. However, only nest boxes up to 7.3 m high were monitored and it is not known whether the trend continues with nest boxes above this height. Menkhorst (1984) found that most species preferred nest boxes that were 4 m or higher. Goldingay (2009) reported that different species use hollows ranging from four to over thirty metres high. However, high nest boxes are more difficult to reach for maintenance, and therefore may be more likely to deteriorate (Beyer and Goldingay 2006; Goldingay and Stevens 2009). This suggests that the optimal placement for nest boxes to provide ongoing habitat should be high enough to meet the requirements of target species, but low enough for maintenance.

The present study also found that nest box occupancy was negatively correlated with tree trunk diameter. This is consistent with Durant *et al.* (2009), who suggested that this could be because fewer hollows are available in smaller trees, while large older trees are more likely to have natural hollows that are preferred by hollow-dependent species. In contrast, Le Roux *et al.* (2016) found no correlation between tree size and occupancy rate.

The distance to nearest tree and nest box stability were not found to be significantly correlated with nest box occupancy, but it is not known whether this reflects real trends or whether it is the result of a limited sample size. It was assumed that nest boxes in areas where tree density was lower, as measured by a greater distance to the nearest tree, would be less likely to be occupied, due to difficulty reaching nest

boxes across open areas. However, even nest boxes at greater distances from other trees contained leaf nests. This may be because all nest boxes were on trees within the maximum gliding distance of gliders, with Squirrel Gliders able to travel around 70 m (NSW Scientific Committee, 2008). It was also assumed that nest box stability would be an important factor influencing occupancy, given the risks of occupying a nest box that may slip or fall. It is not known whether the four unstable nest boxes with signs of occupancy recorded in this study had been abandoned due to instability or if they continued to be used.

The feral Honey Bee hives found in nest boxes may, in the short term, exclude the target vertebrate species from using these boxes. Hives can be removed and nest boxes treated to discourage bees, but this is difficult and would require more resources to be spent on maintenance. However, Goldingay *et al.* (2015) found that, in some areas, Honey Bees will occupy nest boxes only temporarily (less than a year), and Goldingay *et al.* (2020) found that vertebrates wanting to use nest boxes can remove old hives. This suggests that, over the long term, hives may not need to be removed as part of nest box maintenance. It would be useful to monitor nest box use by Honey Bees to determine if this is the case in Warrumbungle NP.

A major area of research in nest box studies is in developing designs to suit the preferences of different species (Beyer and Goldingay 2006; Goldingay and Stevens 2009; Le Roux *et al.* 2016; Saunders *et al.* 2020). This study recorded fauna occupying nest boxes not specifically designed for them, including gliders in Large Parrot nest boxes, and Common Ringtail Possum in a Small Parrot nest box. This demonstrates that nest boxes targeted at particular species can provide suitable habitat for a variety of other animals. Further, in the present study, occupancy was recorded only by arboreal mammals, with no birds, bats or other fauna recorded. It is not known why these species were not using the nest boxes, but seasonal variations in breeding requirements and loss of nearby food resources are possible reasons. Further monitoring would be useful to determine whether these species start using the nest boxes.

### Future management

There are several ways in which this program might be improved in the future. Firstly, there are too many nest boxes in Warrumbungle NP to consistently monitor and maintain with the resources available. Maintenance is also likely to increase as nest boxes deteriorate (Beyer and Goldingay 2006; Goldingay and Stevens 2009; Lindenmayer *et al.* 2009). To allow more consistent monitoring, a different subset could be checked each year, so all are checked every few years; or the total number of nest boxes could be reduced, removing ones that are less likely to be occupied or are difficult to maintain. These could include nest boxes on larger trees and installed lower than preferred by target species, or above the height accessible by the 4.5 m camera pole, and those which are consistently found to be unoccupied. This would also allow the nest boxes to be better maintained and could increase the longevity of the program.

Secondly, the timing of monitoring could be varied. In the present study, monitoring took place only during the summer months. Some species may use nest boxes for only part of the year, such as for breeding, so occupancy may not be detected if monitoring takes place outside this time (Goldingay and Stevens 2009). To explore seasonal variation in nest box occupation, monitoring could be carried out at different times of the year.

### Conclusion

This study aimed to investigate occupancy rates and influencing factors in a post-fire nest box program. The results showed that the rate of overall nest box occupancy was initially low, but increased over the two-year monitoring period, and that there was a significant correlation between nest box occupancy and height above ground, and between occupancy and tree diameter. However, within the power of this study, the distance to nearest tree and stability of the nest box were not found to be correlated. The present study has highlighted possible improvements to the Warrumbungle NP nest box program. The number of nest boxes that were unstable during the study period demonstrates the importance of maintenance to prolong the lifespan of the program. Continued monitoring over the next decade would provide further

insights into factors influencing occupancy, and allow active management to increase the longevity of the nest boxes and further assist in the recovery of hollow-dependent fauna in Warrumbungle NP.

## Acknowledgements

The study was completed with the assistance of Karen Hudson, Rebecca Cass, Sue Brookhouse, and other staff of Coonabarabran NPWS, as well as Michael Murphy, Todd Soderquist and Karl Vernes. We are grateful to Ross Goldingay and an anonymous reviewer for their valuable feedback on the manuscript.

## References

- Adkins MF (2006) A burning issue: using fire to accelerate tree hollow formation in *Eucalyptus* species. *Australian Forestry* 69, 107–113.
- Beyer GL and Goldingay RL (2006) The value of nest boxes in the research and management of Australian hollow-using arboreal mammals. *Wildlife Research* 33, 161–174.
- Brazill-Boast J, Pryke SR and Griffith SC (2013) Provisioning habitat with custom-designed nest-boxes increases reproductive success in an endangered finch. *Austral Ecology* 38, 405–412.
- Clarke H, Lucas C and Smith P (2013) Changes in Australian fire weather between 1973 and 2010. *International Journal of Climatology* 33, 931–944.
- Durant R, Luck SW and Matthews A (2009) Nest-box use by arboreal mammals in a peri-urban landscape. *Wildlife Research* 36, 565–573.
- Ellis MW (2016) Influence of design on the microclimate in nest boxes exposed to direct sunshine. *Australian Zoologist* 38, 95–101.
- Gibbons P and Lindenmayer DB (1996) Issues associated with the retention of hollow-bearing trees within eucalypt forests managed for wood production. *Forest Ecology and Management* 83, 245–279.
- Gibbons P and Lindenmayer DB (2002) *Tree Hollows and Wildlife Conservation in Australia*. (CSIRO: Collingwood).
- Goldingay RL (2009) Characteristics of tree hollows used by Australian birds and bats. *Wildlife Research* 36, 394–409.
- Goldingay RL (2011) Characteristics of tree hollows used by Australian arboreal and scansorial mammals. *Australian Journal of Zoology* 59, 277–294.
- Goldingay RL, Rohweder D, Taylor BD (2020) Nest box contentions: Are nest boxes used by the species they target? *Ecological Management and Restoration* 21, 115–122.
- Goldingay RL, Ruegger NN, Grimson MJ and Taylor BD (2015) Specific nest box designs can improve habitat restoration for cavity-dependent arboreal mammals. *Restoration Ecology* 23, 482–490.
- Goldingay RL and Stevens JR (2009) Use of artificial tree hollows by Australian birds and bats. *Wildlife Research* 36, 81–97.
- Goldingay RL, Thomas KJ, Shanty D (2018) Outcomes of decades long installation of nest boxes for arboreal mammals in southern Australia. *Ecological Management and Restoration* 19, 204–211.
- Harley DKP (2006) A role for nest boxes in the conservation of Leadbeater's Possum (*Gymnobelideus leadbeateri*). *Wildlife Research* 33, 385–395.
- Koch AJ, Munks SA and Woehler EJ (2008) Hollow-using vertebrate fauna of Tasmania: distribution, hollow requirements and conservation status. *Australian Journal of Zoology* 56, 323–349.
- Le Roux DS, Ikin K, Lindenmayer DB, Bistricher G, Manning AD and Gibbons P (2016) Effects of entrance size, tree size and landscape context on nest box occupancy: considerations for management and biodiversity offsets. *Forest Ecology and Management* 366, 135–142.
- Lindenmayer DB, Crane M, Evans MC, Maron M, Gibbons P, Bekessy S and Blanchard W (2017) The anatomy of a failed offset. *Biological Conservation* 210, 286–292.
- Lindenmayer DB, Welsh A, Donnelly C, Crane M, Michael D, Macgregor C, McBurney L, Montague-Drake R and Gibbons P (2009) Are nest boxes a viable alternative source of cavities for hollow-dependent animals? Long-term monitoring of nest box occupancy, pest use and attrition. *Biological Conservation* 142, 33–42.
- Lucas C, Hennessey K, Mills G and Bathols J (2007) Bushfire weather in southeast Australia: recent trends and predicted climate change impacts. Consultancy Report for the Climate Institute of Australia. Bushfire Cooperative Research Centre, Australian Bureau of Meteorology and CSIRO Marine and Atmospheric Research: Melbourne.
- Menkhorst PW (1984) Use of nest boxes by forest vertebrates in Gippsland: acceptance, preference and demand. *Australian Wildlife Research* 11, 255–265.
- NSW Coroner's Court (2015) Inquiry into fire at Wambelong Camp Ground, Warrumbungle National Park, New South Wales, January 2013, file 2013/00052575. State Coroner's Court, Glebe, NSW.
- NSW Scientific Committee (2007) Loss of hollow-bearing trees—key threatening process listing. NSW Scientific Committee, Hurstville. <<https://www.environment.nsw.gov.au/topics/animals-and-plants/threatened-species/nsw-threatened-species-scientific-committee/determinations/final-determinations/2004-2007/loss-of-hollow-bearing-trees-key-threatening-process-listing>> [accessed February 2020].
- NSW Scientific Committee (2008) Squirrel Glider *Petaurus norfolcensis*. Review of current information in NSW, August 2008. Unpublished report arising from the Review of the Schedules of the Threatened Species Conservation Act 1995. NSW Scientific Committee, Hurstville. <<https://www.environment.nsw.gov.au/-/media/OEH/Corporate-Site/Documents/Animals-and-plants/Scientific-Committee/sc-squirrel-glider-petaurus-norfolcensis-review-report.pdf>> [accessed September 2020].
- Office of Environment and Heritage (OEH) (2012) Warrumbungle National Park Plan of Management. NSW Government, OEH, Sydney South.
- Office of Environment and Heritage (OEH) (2015) Nest boxes help natives return to Warrumbungles. Media release. NSW Government, OEH, Sydney South. <<http://www.environment.nsw.gov.au/media/OEHmedia15041300.htm>> [accessed March 2018].
- Office of Environment and Heritage (OEH) (2018) NSW BioNet database. NSW Government, OEH, Sydney South. <<http://www.bionet.nsw.gov.au>> [accessed January 2018].
- Parnaby H, Lunney D and Fleming M (2011) Four issues influencing the management of hollow-using bats of the Pilliga forests of inland New South Wales. In *The Biology and Conservation of Australasian Bats*, pp. 399–420. Eds B Law, P Eby, D Lunney and L Lumsden. (Royal Zoological Society of NSW: Mosman, NSW).
- Saunders DA, Dawson R, Mawson PR and Cunningham RB (2020) Artificial hollows provide an effective short-term solution to the loss of natural nesting hollows for Carnaby's Cockatoo *Calyptorhynchus latirostris*. *Biological Conservation* 245, 1–11.
- van der Ree R, Bennett AF and Soderquist TR (2006) Nest-tree selection by the threatened brush-tailed phascogale (*Phascogale tapoatafa*) (Marsupialia: Dasyuridae) in a highly fragmented agricultural landscape. *Wildlife Research* 33, 113–119.

Submitted 12 March 2020; accepted 12 November 2020

# Scale anomalies in the Little Whip Snake *Suta flagellum* (Elapidae)

Grant S Turner

103 Settlement Road, Bundoora, Victoria 3083.

## Abstract

The occurrence of ventral ('belly') scale anomalies was examined in three populations of the Little Whip Snake *Suta flagellum* in remnant native grasslands near Melbourne. Ventral scale anomalies occurred in similar frequencies in all three populations and overall affected 35% of snakes. Nine types of anomalies were identified, three of which comprised 65% of the affected snakes, and there was a tendency for some types to occur together. The frequency and types of anomalies in the adult and juvenile size classes was similar, indicating that they have little effect on the survival of individuals. Significantly more females than males had ventral scale anomalies and there was also a significant association between sex and the location of anomalies, with males having significantly more subcaudal (tail) scale anomalies than females. Half-scale anomalies occurred more frequently on the left than on the right side. The possible significance of the ventral scale anomalies is discussed. (*The Victorian Naturalist* 138 (2), 2021, 45–52)

**Keywords:** scale anomalies, frequencies, types, ventral, subcaudal

## Introduction

In snakes, anomalous or abnormal scales have been documented in a wide variety of taxa; most of these have been located on the head and also on the ventral surface ('belly') of snakes rather than on the body (Martof 1954; Barton 1956; King 1959; Clarke and Callison 1967; Peters 1969; Plummer 1980; Murphy *et al.* 1987; Arnold and Bennett 1988; Schwaner 1990; Merilä *et al.* 1992; Lindell *et al.* 1993; Shine *et al.* 2005; Laia *et al.* 2015; Brown *et al.* 2017). Ventral scales are the repetitive series of enlarged transverse scales that extend from the underside of the neck through to the tail tip. Anomalous ventral scales have been shown to occur either as a consequence of embryos being subjected to temperature extremes or as an expression of abnormal genetic control of development (Fox 1948; Fox *et al.* 1961; Vinegar 1973, 1974; Osgood 1978; Plummer 1980; Murphy *et al.* 1987; Brown *et al.* 2017). They can be the external manifestation of underlying skeletal deformities, such as the duplication of ribs (King 1959; Osgood 1978; Schwaner 1990; Merilä *et al.* 1992; Löwenborg *et al.* 2011). Skeletal deformities have been shown to affect locomotor performance and survival in snakes (Arnold and Bennett 1988; Jayne and Bennett 1990; Forsman *et al.* 1994). The overall frequency of anomalies (or gross abnormalities) in snake populations is one of several measures of embryonic developmental stability in reptile populations (Sarre and Dearn 1991; Forsman *et al.* 1994; Löwenborg *et al.* 2011).

There are few studies of scale anomalies in Australian snakes. Schwaner (1990) presented an analysis of scale and underlying skeletal anomalies in insular and mainland populations of the Tiger Snake *Notechis scutatus*. Schwaner *et al.* (1988) also examined insular populations of Carpet Pythons *Morelia spilota imbricata* and found a high proportion of individuals possessed ventral scale anomalies though the sample size was small. Brown *et al.* (2017) made a comprehensive study of two types of head scale anomalies (asymmetry and fragmentation) in the Slaty-grey Snake *Stegonotus cucullatus* and found that scale asymmetry was directional (favouring left over right) and that scale fragmentation was more prevalent in females than males. Shine *et al.* (1988) observed individual variation in the number and position of anomalous subcaudal scales in Red-bellied Black Snakes *Pseudechis porphyriacus* and Water Pythons *Liasis fuscus* and discussed their use as natural markers in mark-recapture studies. Several authors mention the occurrence of ventral scale anomalies incidentally, when describing individual snakes (e.g. Trinca *et al.* 1971; Schofield 1972).

This work is concerned with a description of the types, frequency, and patterns of occurrence of anomalous ventral scales in the Little Whip Snake *Suta flagellum*. This species is a small, nocturnal, live-bearing elapid snake found throughout much of Victoria, south-eastern NSW and the south-east corner of SA

and is a particularly common inhabitant of basalt plains grasslands near Melbourne (McCoy 1878; Rawlinson 1965; Jenkins and Bartell 1980; Cogger 2014; Robertson and Coventry 2019). Elapid snakes have undivided ventral scales between the neck and the vent, while those on the underside of the tail (called subcaudal scales) may be divided or undivided (or a combination of both) depending on the species (Greene 1997; Shea *et al.* 1993; Cogger 2014). *Suta flagellum*, along with all other species of the genus *Suta*, is distinguished as having an entire anal scale and undivided subcaudal scales (Rawlinson 1965; Coventry and Robertson 1991; Cogger 2014). Male and female *S. flagellum* have the same body length (Shine 1988; Turner 2019) but males have significantly longer tails (Turner 2019) and hence larger numbers of subcaudal scales compared to females (males 29–40, females 20–29;  $n = 68$ ; Rawlinson 1965). Several authors had previously noted the occurrence of anomalous ventral scales in *S. flagellum*, but their types and frequency were not examined (McCoy 1878; Rawlinson 1965; Turner 1989).

## Methods

As part of a population census of *S. flagellum*, three disjunct populations occurring on the basalt plains to the north and west of Melbourne at Bundoora (37°42' S, 145°03' E), Somerton (37°38' S, 144°58' E) and Deer Park (37°46' S, 144°46' E) were examined from 1990 to 1994. Sampling was conducted throughout all months of the year. The snout-to-vent length (SVL) was measured to the nearest millimetre and snakes were classed as either juvenile (=immature) or adult on the basis of the known sizes at sexual maturity (males  $SVL \geq 205$  mm, females  $SVL \geq 232$  mm; Shine 1988). Sex was determined by visual examination of the tail shape (see Turner 1992, 1999). The habitat at each locality consisted of remnant native grassland of varying quality with abundant surface basalt rock, some exfoliations, dry stone walls and stony rise. The approximate area of the sites were: 80 ha (Bundoora), 100 ha (Somerton), and 250 ha (Deer Park). Each was surrounded by housing/industrial estates and/or farmland. For more detailed site descriptions and methodology, see Turner (2019).

Snakes were inspected for the presence of anomalous scales on the head, dorsal, lateral and ventral surfaces. For each snake, anomalies were hand-drawn and later grouped into a number of different types, and the number of anomalies and their location (anterior/mid/posterior body, ventral or subcaudal) was recorded. In snakes with multiple scale anomalies, the anomaly type(s) and the number of each anomaly type were recorded. Herein, 'ventral scales' refer to all scales on the underside of the body and tail (i.e. including the vent and subcaudal scales) while 'pre-anal scales' refer to just the three ventral scales immediately before (i.e. anterior to) the anal scale.

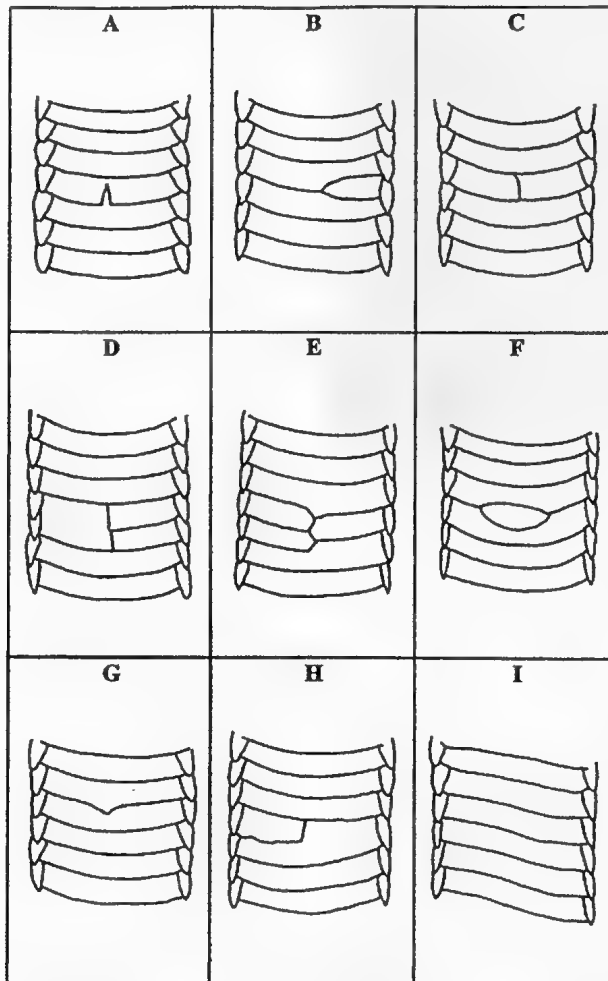
Statistical tests were employed to test for associations between the incidence of anomalies and factors such as size class, sex, location of anomalies, etc. The G-test for goodness of fit with William's correction was used to test deviations from expected frequencies in both single and two-way classifications (i.e.  $2 \times 2$ ,  $3 \times 2$  contingency tables; Sokal and Rohlf 1981). The Student *t*-test was used to compare the means of normally distributed data, and the resulting probabilities were two-tailed. As multiple statistical tests were performed, FDR control (Benjamini and Hochberg 1995) was employed globally on the results, but did not change the significance of any result at the  $\alpha = 0.05$  level; probabilities quoted below are therefore unaltered.

## Results

The overall frequency of ventral scale anomalies obtained from pooling all data (over sex, size class and population) was 35.2% (160 affected;  $n=455$ ). Most affected snakes had a single anomaly (57.8%) while those with more than six anomalies were uncommon (5.2%; see Table 1—there were six snakes in which the number of anomalies was not determined). This latter figure included five individuals with large numbers of anomalies (from 10 to 22), and three stillborn neonates each with more than 10 anomalies and gross deformities (Turner 1998). When these individuals are excluded, as they are from all the analyses below, a total of 242 ventral scale anomalies affecting 146 individuals were recorded with an average 1.66 scale anomalies per individual.

**Table 1.** Frequency and percentage frequency occurrence of the number of ventral scale anomalies in the Little Whip Snake *Suta flagellum*.

No. Anomalies	1	2	3	4	5	6	>6	Total
Frequency	89	32	16	6	1	2	8	154
% Frequency	57.8	20.8	10.4	3.9	0.6	1.3	5.2	100

**Fig. 1.** The nine types of anomalous ventral scales recorded in the Little Whip Snake *Suta flagellum*.**The types and frequency of anomalies**

Nine types of ventral scale anomalies were identified (Fig. 1). Some types of ventral scale anomalies represent a breaking of bilateral symmetry, a state in which the left and right sides of the body are identical (or nearly so). Types B, D, E and H (see Figs. 1 and 2) are examples of

such asymmetries, whereas types A, C, F and G are not (see comments on type I below). Type A and C anomalies consisted of scales divided into right and left halves (sometimes referred to as 'cleft' scales in the literature) with no overlap and some overlap respectively between the halves. They did not occur in conjunction

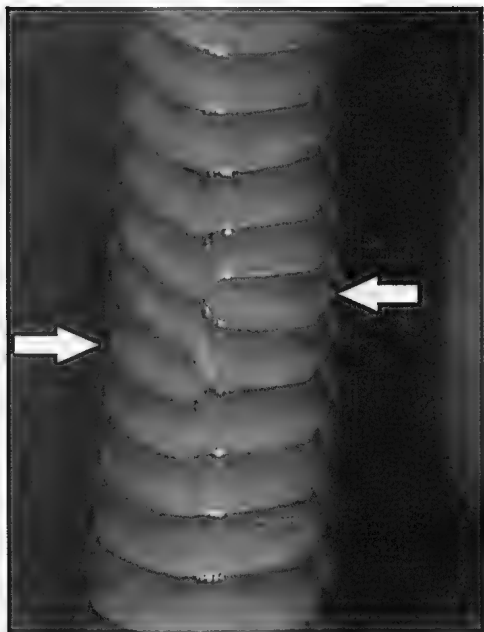


Fig 2. Two type B (half-scale) anomalies (indicated by arrows) on the anterior ventral surface of an adult male Little Whip Snake *Suta flagellum*.

with any other types of anomalies. Type B and H anomalies consisted of the imposition of a half-scale on one side of the body while type E consisted of the imposition of two half-scales on one side of the body; one or more of these anomalies occurred in individual snakes. Type D anomalies consisted of two consecutive ventral scales in which one half of each scale was fused together. Type F anomalies consisted of incompletely formed ventral scales that did not contact the dorsal scale row. Type I anomalies consisted of scales with an uneven leading edge. This anomaly type typically affected multiple, consecutive ventral scales (but only one scale was counted as being affected in the analyses above) and they always occurred in conjunction with symmetry-breaking anomalies. Type G anomalies consisted of a leading edge with a cusp and typically occurred singly.

The percentage frequencies of each anomaly type were: A 10.2%, B 41.8%, C 9.6%, D 13.0%, E 6.2%, F 7.3%, G 4.5%, H 4.0% and I 3.4%. Anomaly types A, B and D together comprised 65% of the total. Types B, D, E and H were more common on the left-hand rather than the

right-hand side of the ventral surface ( $t$ -test (paired)=2.76, 93df,  $P=0.007$ ). If the analysis is restricted to just type B anomalies the result is marginally significant ( $t$ -test (paired)=2.01, 78df,  $P=0.048$ ). In an adult snake with the largest number of anomalous scales ( $n=22$ ) only types B, D and I were exhibited. No individuals exhibited all anomaly types, though up to four types were recorded in one snake. In snakes with multiple anomalies ( $n=65$ ), some patterns were evident between certain types, though statistical analysis was not conducted due to the small sample size. For example, type B anomalies were most likely to occur with another of the same type ( $n=15$ ) rather than a different type ( $n \leq 5$  for all others). Type I anomalies most often occurred immediately following types B, E or H or were interspersed between these types ( $n=10$ ). The leading-edge of scales with type I anomalies were observed to 'straighten-out' before the formation of other types of anomalies in some snakes ( $n=7$ ).

All types of scale anomalies were represented in each of the three populations, with one exception. Type A anomalies were not recorded in the Somerton population but were relatively common in the Deer Park and Bundoora populations.

### The incidence of anomalies

- (i) *Populations*: anomalies in each of the three populations were found to occur in the following frequencies: Deer Park 30.3%, Bundoora 39.7% and Somerton 29.8%. There was no association between population and the frequency of anomalies ( $3 \times 2$  contingency table:  $G=2.14$ , 2df,  $P=0.343$ ). For this reason, and also because the types of anomalies and the frequency of those types were very similar, the population data was pooled in the analyses below.
- (ii) *Size class*: adult and juvenile snakes exhibited similar frequencies of ventral scale anomalies: 54% ( $n=86$ ) and 46% ( $n=74$ ) respectively ( $G=0.90$ , 1df,  $P=0.342$ ). There was no association between size class and the occurrence of anomalies ( $2 \times 2$  contingency table:  $G=0.28$ , 1df,  $P=0.595$ ).
- (iii) *Sex*: significantly more females than males possessed anomalies ( $G=9.27$ , 1df,  $P=0.002$ ). This result was significant in both the adult and juvenile size classes ( $2 \times 2$  contingency

tables—adults:  $G=6.65$ , 1df,  $P=0.010$ ; juveniles:  $G=6.73$ , 1df,  $P=0.009$ ). When size classes were combined there was a highly significant association between sex and the incidence of anomalies ( $2 \times 2$  contingency table:  $G=13.19$ , 1df,  $P=0.0003$ ). Mean numbers of anomalies per individual was 1.6 for females and 1.7 for males and these were not significantly different ( $t=0.591$ , 111df,  $P=0.556$ ). There was no association between sex and whether anomalies occurred singly or multiply ( $2 \times 2$  contingency table:  $G=0.116$ , 1df,  $P=0.773$ ).

- (iv) *Location*: anomalous ventral scales occurred more commonly on the posterior third of the body (especially the last 20 scales before the vent and the subcaudal scales) with 72% (113 of 157) located there. This distribution departed significantly from uniformity ( $G=97.4$ , 1df,  $P<0.0001$ ). Of all anomalies, 63% were restricted to ventral scales between the head and the vent and no anomaly type was restricted to either these scales or the subcaudal scales. Anomalous ventral pre-anal scales were common, representing 35.7% of all anomalies, followed by subcaudal scale anomalies (22.9%). Anomalous scales on the mid and anterior body were uncommon, comprising 5.7% and 13.6% of all anomalies respectively. Approximately one-quarter (26.8%) of all subcaudal scale anomalies affected the first three subcaudal scales. Three snakes had a divided anal scale (2.1%).

#### **Analysis of affected snakes: interactions between factors**

Tests of association between size class, sex, location and anomaly type revealed only one strong association, which was between the location of ventral scale anomalies (categories: ventral scales excluding pre-anal scales,

pre-anal scales + anal scale, subcaudal scales) and sex ( $3 \times 2$  contingency table:  $G=17.16$ , 2df,  $P=0.0002$ ; see Table 2). When the subcaudal scales are excluded from the analysis, there was a marginally significant association between the presence/absence of ventral scale anomalies and sex due to females possessing significantly more anomalies than males ( $2 \times 2$  contingency table:  $G=3.98$ , 1df,  $P=0.046$ ). Conversely there was a strong association between the presence/absence of subcaudal scale anomalies and sex ( $2 \times 2$  contingency table:  $G=7.53$ , 1df,  $P=0.006$ ) with males possessing significantly more anomalies than females. This indicates that subcaudal scale anomalies provided the main contribution to the strong association between the location of ventral scale anomalies and sex. Anomaly type and size class were not significantly associated with any other variable (Table 2).

#### **Other scale anomalies**

Several other types of anomalous scales occurred, albeit rarely, and were not included in the above analyses. An indented line or crease running down the middle of the ventral surface, usually terminating at the vent, was observed in six snakes. Enlarged and sometimes irregularly shaped dorsal scales were also recorded singly ( $n=5$ ). Some head scale anomalies were observed: in one neonate a scale was fused to the left parietal scale (enlarged head scale) while in five other (adult) snakes the suture separating the left and right parietals was incompletely formed. Additionally, variations in the number of scales abutting the left versus the right parietal scales (see Brown *et al.* 2017) were noted but were not considered in this study. There were also instances of small amelanotic (white or cream) patches on ventral and subcaudal scales ( $n=15$ ).

**Table 2.** Tableaux containing the probabilities from contingency table G-tests of association between the four anomalous ventral scale variables in the Little Whip Snake *Suta flagellum*. Statistically significant results (i.e.  $P<0.05$ ) are in bold type.

	Size Class	Sex	Location	Type
Size Class	–	0.435	0.155	0.172
Sex		–	<b>0.0002</b>	0.713
Location			–	0.547
Type				–

## Discussion

Whether the ventral scale anomalies documented in *S. flagellum* originate from the disruption of normal development (a consequence of environmental disturbances for instance), genetic stress (resulting from a loss of genetic diversity or drift) or a combination of both has not been determined in this work. In *S. flagellum* the overall percentage frequency of anomalies was relatively high (35%) but falls within the broad range reported in other studies of snakes (15% to 92%, though some sample sizes were small; Plummer 1980; Schwaner 1990; Merilä *et al.* 1992; Forsman *et al.* 1994). The high frequency of anomalies in *S. flagellum* would suggest some degree of environmental and/or genetic stress in the populations studied. To determine if this is the case, a comparison with a relatively large and undisturbed population of *S. flagellum* would be useful in establishing the natural or 'background' frequency of anomalies. Alternatively, the examination of museum specimens, which originate from multiple locations, populations and times, might also be useful in determining some measure of the natural frequency of anomalies, though sample size might limit the feasibility of this estimate (Museums Victoria 2020: 288 specimens and only approximately 40% of these are from locations on the basalt plains). Estimates of heterozygosity (i.e. genetic diversity) of each population in this study would also have been informative (though is now not possible for two of the populations due to localised extinctions, and fragmentation of the third) as studies have consistently shown an inverse (negative) relationship between the occurrence of anomalies and heterozygosity (Parsons 1990; Schwaner 1990). In *S. flagellum*, the frequency of anomalous ventral scales did not differ significantly between populations; however, it may be notable that the highest frequency of anomalies occurred in the smallest population whose habitat was subject to the greatest (anthropogenic) disturbance.

All six ventral scale anomalies identified by Peters (1969) were among the nine types identified in this work (type 1=B, type 2=C, type 3=H, type 4=F, type 5=D, type 6=A) while the further three anomalies in this study (types E, G and I) were not. The predominance of type B anomalies in *S. flagellum* was consistent with

other studies (types B and C, Peters 1969; types B, C and H, Schwaner 1990; types B and A, and possibly type C also, Merilä *et al.* 1992; type B, Plummer 1980). Most, but not all studies (e.g. Schwaner 1990), have found a high proportion of pre-anal scale anomalies (Plummer 1980, Merilä *et al.* 1992, Shine *et al.* 2005) as in this work, although a significant proportion of anomalies was also found to affect subcaudal scales in *S. flagellum* (22.9% versus 35.7%). Forsman *et al.* (1994) found some evidence that mid-body anomalies may be more deleterious than those located elsewhere on the ventral surface. Given the similarity of most anomaly types in this work to those found in other studies, where anomalies were shown to be a manifestation of underlying skeletal deformities, it is likely that type B, E and H anomalies represent the duplication of a rib on one side of the body, while type D anomalies could represent the omission of rib on one side of the body. Plummer (1980) stated that the predominance of one anomaly type and its consistent location on the body of individuals favoured a genetic rather than an environmental cause. In *S. flagellum* type B anomalies occurred with at least four times the frequency of any other type, and almost 60% of anomalies occurred on either the pre-anal or subcaudal scales (i.e. near or on the ventral tail surface) which may suggest that these anomalies in *S. flagellum* are controlled genetically. However, the tendency for type B anomalies to occur more frequently on one side (left) of the ventral surface, would seem to contradict this as the same genes are known to control development on both sides of the body (Löwenborg *et al.* 2011).

The tendency for asymmetries to occur significantly more often on the left-hand side of the ventral surface rather than the right in *S. flagellum* indicates directional rather fluctuating asymmetry (see Parsons (1990) and Palmer (1994) for a detailed discussion of asymmetry types). This tendency has been recorded in several other snake species in which anomalies were correlated with corresponding asymmetries in the male reproductive system, less mating success, a higher incidence of tail injuries, slightly lower survival and higher growth rates (Shine *et al.* 2000; Shine *et al.* 2005; Razzetti *et al.* 2007; Brown *et al.* 2017).

A significantly higher frequency of scale anomalies in one sex has been reported in only a few studies (Arnold and Peterson 2002; Shine *et al.* 2005; Brown *et al.* 2017). Significantly more female than male *S. flagellum* possessed ventral scale anomalies. Sex bias is unlikely to be explained by environmental factors affecting development as such factors should operate equally on both sexes *in utero* and so is consistent with a genetic origin of anomalies in *S. flagellum*. However, the main contribution to the significant association between sex and the location of anomalies was due to males having more subcaudal scale anomalies compared to females, which in turn may be due to males having longer tails (and hence higher numbers of subcaudals). Further studies need to include subcaudal scale counts in order to resolve this point.

It is unlikely that the ventral scale anomalies observed in *S. flagellum* have any direct functional significance, with only small numbers of anomalies occurring in the majority of affected snakes. Some scale anomalies, however, are known to reduce the fitness of individuals, leading to differential survival in the wild (Dunn 1942; Inger 1942, 1943; Forsman *et al.* 1994). Examples of *S. flagellum* with large numbers of anomalies were observed in this study, and have been reported in several other species, though often in conjunction with more severe and lethal deformities (Bellairs 1965; Pendlebury 1976; Turner 1998). The similar frequency and types of anomalies occurring in the adult and juvenile size classes in *S. flagellum* would indicate that anomalies do not significantly affect survival, though whether they affect other components of fitness (e.g. reproduction) is unknown. The high frequency of anomalies reported in some populations has led to the suggestion that ventral scale anomalies do not confer a great selective disadvantage to their carriers (Plummer 1980; Merilä *et al.* 1992). Forsman *et al.* (1994) examined the influence of scale anomalies on survival in Adders *Vipera berus* and determined a significant difference in the frequency of mid-body scale anomalies between captive-born neonates and wild juveniles. They argued that anomalies may commonly persist despite strong selection against them if: (i) they result primarily from environmental stress, and (ii)

the position of anomalies determines their effect on fitness.

Scale anomalies in *S. flagellum* can provide a natural, permanent marker and are a useful adjunct in identifying individual snakes. Shine *et al.* (1988) described the use of anomalous subcaudal scales in identifying individual snakes in mark-recapture studies of two snake species in which there was sufficient variability in anomaly type and position. Brown *et al.* (2017) recorded the presence/absence of ventral-scale anomalies on the posterior quarter of the body, in addition to scale-clipping, to assist with the identification of individual snakes. In *S. flagellum* the tendency for anomalies to occur in particular locations (e.g. pre-anal scales) and to consist mainly of only a few types, limits their use as natural identification markers. Nonetheless these anomalies have been successfully used in conjunction with other identifiers such as sex, ventral coloration, and snout band pigment for this purpose (Turner, unpublished data 1990–94).

### Acknowledgements

I wish to thank Dr Allen Greer and Professor Rick Shine for providing me with several of the references cited. I also thank the referees for their improvements to the manuscript.

### References

- Arnold S and Bennett A (1988) Behavioral variation in natural populations. V. Morphological correlates of locomotion in the Garter snake (*Thamnophis radix*). *Biological Journal of the Linnean Society* **34**, 175–190.
- Arnold SJ and Peterson CR (2002) A model for optimal reaction norms: the case of the pregnant garter snake and her temperature-sensitive embryos. *American Naturalist* **160**, 306–316.
- Barton AJ (1956) A statistical study of *Thamnophis brachystoma* (Cope) with comments on the kinship of *T. butleri* (Cope). *Proceedings of the Biological Society Washington* **2**, 77–88.
- Bellairs A d'A (1965) Cleft palate, microphthalmia and other malformations in embryos of lizards and snakes. *Proceedings of the Zoological Society (London)* **144**, 239–251 (plus plates).
- Benjamini Y and Hochberg Y (1995) Controlling the false discovery rate—a practical and powerful approach to multiple testing. *Journal Royal Statistical Society B* **57**, 289–300.
- Brown GP, Madsen T, Dubey S and Shine R. (2017) The causes and ecological correlates of head scale asymmetry and fragmentation in a tropical snake. *Scientific Reports* **7**, Article no. 11363, 1–11.
- Clarke DR and Callison, GL (1967) Vertebral and scute anomalies in a Racer, *Coluber constrictor*. *Copeia* **1967**, 862–864.
- Cogger HG (2014) *Reptiles and Amphibians of Australia* (7th edn.). (Reed: Chatswood).
- Coventry AJ and Robertson P (1991) *The Snakes of Victoria*. (Conservation and Environment/Museum of Victoria: Melbourne).

- Dunn ER (1942) Survival value of varietal characters in snakes. *American Naturalist* 76, 104–109.
- Forsman A, Merilä J and Lindell LE (1994) Do scale anomalies cause differential survival in *Vipera berus*? *Journal of Herpetology* 28, 435–440.
- Fox W (1948) Effect of temperature on development of scutellation in the Garter snake, *Thamnophis elegans atratus*. *Copeia* 1948, 252–262.
- Fox W, Gordon C and Fox MH (1961) Morphological effects of low temperatures during the embryonic development of the Garter snake *Thamnophis elegans*. *Zoologica* 46, 57–71.
- Greene HW (1997) *Snakes: the evolution of mystery in nature*. (University of California Press: Berkeley, California).
- Inger RF (1942) Differential selection of variant juvenile snakes. *American Naturalist* 76, 527–528.
- Inger RF (1943) Further notes on differential selection of variant juvenile snakes. *American Naturalist* 77, 87–90.
- Jayne BC and Bennett AF (1990) Selection on locomotor performance capacity in natural populations of Garter snakes. *Evolution* 44, 1204–1229.
- Jenkins RWG and Bartell RJ (1980) *A Field Guide to the Reptiles of the Australian High Country*. (Inkata Press: Melbourne).
- King W (1959) Vertebra duplication, an osteological anomaly widespread in snakes. *Herpetologica* 15, 87–88.
- Laia RC, Pinto MP, Menezes VA and Rocha CFD (2015) Asymmetry in reptiles: what do we know so far? *Springer Science Reviews* 3, 13–26.
- Lindell LE, Forsman A and Merilä J (1993) Variation in number of ventral scales in snakes: effects of body size, growth rate and survival in the adder, *Vipera berus*. *Journal of Zoology (London)* 230, 101–115.
- Löwenborg K, Shine R and Hagman M (2011) Fitness disadvantages to disrupted embryogenesis impose selection against suboptimal nest-site choice by female Grass snakes, *Natrix natrix* (Colubridae). *Journal of Evolutionary Biology* 24, 177–183.
- Martof, B (1954) Variation in a large litter of Garter snakes, *Thamnophis sirtalis sirtalis*. *Copeia* 1954, 100–105.
- McCoy F (1878) Hoplocephalus flagellum (McCoy)—The Little Whip snake. In *Natural History of Victoria: Prodromus of the Zoology of Victoria 1878–90, Decade II*, pp. 7–8 plus Plate 11. (J Ferres, Government Printer: Melbourne).
- Merilä J, Forsman A and Lindell LE (1992) High frequency of ventral scale anomalies in *Vipera berus* populations. *Copeia* 1992, 1127–1130.
- Murphy JB, Rehg GE, Maderson PFA and McCrady WB (1987) Scutellation and pigmentation defects in a laboratory colony of Western Diamondback Rattlesnakes (*Crotalus atrox*): mode of inheritance. *Herpetologica* 43, 292–300.
- Museums Victoria (2020) Museums Victoria Collections <<https://collections.museums.victoria.com.au/search?query=Suta+flagellum&recordtype=specimen&page=3>> [accessed 4 October 2020].
- Osgood DW (1978) Effects of temperature on the development of meristic characters in *Natrix fasciata*. *Copeia* 1978, 33–47.
- Palmer AR (1994) Fluctuating asymmetry analyses: a primer. In *Developmental Instability: its origins and evolutionary implications*, pp. 335–364. Ed TA Markow. (Kluwer: Dordrecht).
- Parsons PA (1990) Fluctuating asymmetry: an epigenetic measure of stress. *Biological Reviews* 61, 131–145.
- Pendlebury GB (1976) Congenital defects in the brood of a prairie rattlesnake. *Canada Journal of Zoology* 54, 2023–2025.
- Peters JA (1969) The snakes of the family Dipsadinae. *Miscellaneous Publications University of Michigan Museum of Zoology* 114, 1–224.
- Plummer MV (1980) Ventral scute anomalies in a population of *Ophedrys aestivus*. *Journal of Herpetology* 14, 199.
- Rawlinson P (1965) Snakes of the Melbourne area. *The Victorian Naturalist* 81, 245–254.
- Razzetti E, Faiman R and Werner YL (2007) Directional asymmetry and correlation of tail injury with left-side dominance occur in Serpentes (Sauropsida). *Zoomorphology* 126, 31–43.
- Robertson P and Coventry AJ (2019) *Reptiles of Victoria—a guide to identification and ecology*. (CSIRO Publishing: Clayton South, Victoria).
- Sarre S and Dearn JM (1991) Morphological variation and fluctuating asymmetry among insular populations of the Sleepy lizard, *Trachydosaurus rugosus* Gray (Squamata: Scincidae). *Australian Journal of Zoology* 39, 91–104.
- Schwanner TD (1990) Geographic variation in scale and skeletal anomalies of Tiger snakes (Elapidae: *Notechis scutatus-ater* Complex) in Southern Australia. *Copeia* 1990, 1168–1175.
- Schwanner T, Francis M and Harvey C (1988) Identification and conservation of Carpet pythons (*Morelia spilota imbricata*) on St. Francis Island, South Australia. *Herpetofauna* 18, 13–20.
- Schofield W (1972) Notes on the birth of Red-Bellied Black snakes. *Herpetofauna* 5, 20–22.
- Shea G, Shine R and Covacevich JC (1993) Family Elapidae. In *Fauna of Australia—Volume 2A Amphibia and Reptilia*, pp. 295–309. Eds CJ Glasby, GJB Ross and PL Beesley. (Australian Government Publishing Service: Canberra, ACT).
- Shine C, Shine N, Shine R and Slip D (1988) Use of scale anomalies as an aid in recognising individual snakes. *Herpetological Review* 19, 79–80.
- Shine R (1988) Food habits and reproductive biology of small Australian snakes of the genera *Unechis* and *Suta* (Elapidae). *Journal of Herpetology* 22, 307–315.
- Shine R, Langkilde T, Wall M and Mason RT (2005) The fitness correlates of scalation asymmetry in Garter snakes *Thamnophis sirtalis parietalis*. *Functional Ecology* 19, 306–314.
- Shine R, Olsson MM, Moore IT, LeMaster MP and Mason RT (2000) Are snakes right-handed? Asymmetry in hemipenis size and usage in Garter snakes (*Thamnophis sirtalis*). *Behavioural Ecology* 11, 411–415.
- Sokal RR and Rohlf FJ (1981) *Biometry*. (Freeman: New York).
- Trinca JC, Graydon JJ, Covacevich J. and Limpus C. (1971) The Rough-scaled snake (*Tropidechis carinatus*) a dangerously venomous snake. *Medical Journal of Australia* 2, 801–809.
- Turner G (1989) Observations of *Unechis flagellum* (Elapidae). *Herpetofauna* 19, 1–7.
- Turner G (1992) Courtship behaviour and male combat in the Little Whip Snake *Rhinoplocephalus flagellum* (Elapidae). *Herpetofauna* 22, 14–21.
- Turner G (1998) Congenital anomalies in the Little Whip Snake *Suta flagellum* (Elapidae). *Monitor—Journal of the Victorian Herpetological Society* 10, 15–17.
- Turner G (1999) A novel method of identifying sex in neonate Little Whip Snakes *Suta flagellum* (Elapidae). *Herpetofauna* 29, 10–12.
- Turner GS (2019) Notes on the natural history of the Little Whip Snake, *Parasuta flagellum* (Elapidae) from basalt plains grasslands near Melbourne. *The Victorian Naturalist* 136, 128–142.
- Vinegar A (1973) The effects of temperature on the growth and development of embryos of the Indian python *Python molurus* (Reptilia: Serpentes: Boidae). *Copeia* 1973, 171–173.
- Vinegar A (1974) Evolutionary implications of temperature induced anomalies of development in snake embryos. *Herpetologica* 30, 72–74.

Submitted 10 October 2019; accepted 10 October 2020

## Further observations of Australasian Grebe *Tachybaptus novaehollandiae* activity on two waterbodies in Clayton, Victoria

### Introduction

This article adds to observations of Australasian Grebe *Tachybaptus novaehollandiae* activity at Monash University's Clayton campus, in suburban Melbourne, Victoria (Fig. 1), reported in *The Victorian Naturalist* 135 (4) (Hubregtse 2018). My husband (Jurrie) and I continued our opportunistic observations during walks at two locations on the campus, namely the flood-retarding basin and the nearby waterbody in Jock Marshall Reserve. During 2018, for the first time since 2006, no breeding took place at the basin, while two attempts at Jock Marshall Reserve were unsuccessful. Some behaviours not observed previously were noted, including interactions with other birds and the response of two Grebes to a third that had become entangled in a piece of plastic rubbish.

### Activity at the basin 2018–2020 2018

#### Parent and youngster

Of particular interest were the parent Grebe and its youngster, which was the sole survivor of a brood that hatched at the end of December 2017 and stayed with its parent much longer than the usual eight or nine weeks. At eight weeks of age, this bird tried to present a piece of waterweed to its parent (Hubregtse 2018). According to Marchant and Higgins (1990) and Fjeldså (2004), this is courtship behaviour. Presumably a bird would present to the opposite sex rather than to a bird of the same sex, so it seemed that these birds were possibly mother and son. They kept company at the basin until mid-September. From 18 to 21 July they started to build a flimsy platform, but soon lost interest in it. On 14 August they were seen swimming and diving in unison, and on 2 September one was chasing the other. It seemed as though either (1) the younger bird wanted to mate and the parent didn't, or (2) the parent was trying to persuade its offspring to leave. Maybe the younger bird had the avian equivalent of Oedipus complex! Anyway, one of them left about 15 September, and the other, which was just



Fig. 1. An Australasian Grebe family at the flood-retarding basin, Monash University, Clayton, Victoria.

sitting still in the water during five subsequent observations, left on 3 or 4 October.

#### Comings and goings

Australasian Grebes move around a lot, and unless there is a difference in plumage it is difficult to tell them apart. On 13 October an immature Grebe was present, but was seen only once. Two adults were present from 17 October to 10 November, and three on 17 November. There were two on 18 November, but from 22 November until 30 January 2019 only one was seen.

### 2019

#### Nest failure

Two Grebes were present on 31 January, and on 6 February one was on a nest in the bulrushes *Typha* sp. at the western end of the basin. Rain fell on 6 and 9 February, and the nest disappeared, probably destroyed by flash flooding. Only one Grebe was seen from this time until the end of March, but two were present from 3 April onwards. On a couple of occasions during May and June, the presence of a third, obviously unwelcome, adult generated a lot of chasing and splashing.

#### Partial nesting success

From 12 August to 25 November only one bird was seen, but its behaviour indicated that a second one was on a nest in the bulrushes at the western end of the basin. On 26 November two

Grebes emerged from the bulrushes to join in a dispute between Eurasian Coots *Fulica atra* and Dusky Moorhens *Gallinula tenebrosa*, both of which had chicks and were uncomfortably close to the Grebes' nest. This was the first time we had seen Grebes interacting with Dusky Moorhens. After the disagreement was over, one Grebe retreated into the bulrushes. On 29 November both Grebes were seen with their brood of three, the youngest of which appeared to be about one week old. This confirmed our suspicion that the parents had been concealing their chicks in the bulrushes until they were 'considered' old enough to venture into the open water; some pairs of Grebes are much more cautious than others in this regard (pers. obs.). One of the chicks was not seen again, and a second was not seen after 14 December. The third was still present on 21 January 2020, but not on 24 January, when it would have been about nine weeks old and may have departed. The two adults were nesting in the bulrushes again by 27 December.

## 2020

### Partial success again

On 24 January, two chicks, only a day or two old, were clearly visible on the nest platform. They were exposed because the tall bulrushes that previously obscured the nest had been dislodged. To make matters worse, on the previous day rain laden with dust from a dust storm had precipitated red soil everywhere, and water washing the soil in from the surrounding area made the basin very murky (Fig. 2 shows the state of the water four days later), and probably restricted the adult Grebes' chances of locating food.

By 26 January one of the chicks had vanished, and the parents were obviously having difficulty finding food. They were seen at the shallow, eastern end of the basin, where dive after dive produced no food items. On 27 January the adults chased away a Pacific Black Duck *Anas superciliosa* that seemed to be getting too close to their remaining chick. This was the first time we had seen Grebes interacting with this species.

On 1 February heavy rain washed more red mud into the basin (Fig. 3). The two adult Grebes and their youngster were still there until 16 March, after which one adult (presumably)

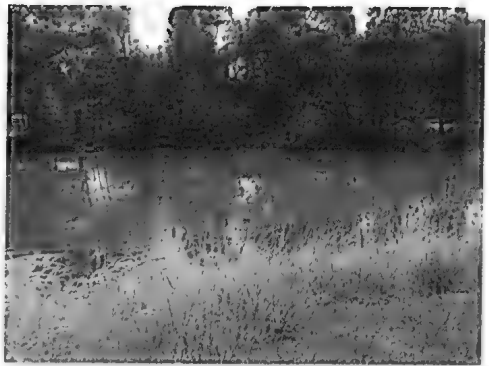


Fig. 2. Muddy water in the basin, 27 January 2020.



Fig. 3. More muddy water in the basin, 1 February 2020.

left. The youngster was last seen on 22 March; since it was just over eight weeks old, it may have departed. The remaining adult was present on 30 March, but was not seen on 2 April, when observations ceased temporarily because of the COVID-19 virus pandemic.

### Three Grebes, one plastic-wrapped

From 16 May to the time of writing (17 June 2020) three adult Grebes were present and all seemed to get along well, keeping together most of the time. On 7 June one became entangled in a piece of plastic rubbish, and was chased relentlessly by the other two—apparently they objected to the changed appearance and abnormal movements of their companion. If the situation hadn't changed, the plastic-coated bird would have been doomed, because it couldn't swim properly or dive, and its distress was exacerbated by constant harassment from its fellows. Fortunately, after much struggling,

it managed to escape from the dangerous wrapping, then swam away from the other birds and had a bath and a rest. On the following day all three were together again, being just as 'friendly' as they had been before the entanglement.

#### Activity at Jock Marshall Reserve 2018–2020 2018

##### *Nesting attempt and loss of chicks*

One adult Grebe was present from 9 June. An immature Grebe was there on 5 September. Both birds were together for nearly 12 weeks, and by 19 September the immature one was developing breeding plumage. (In this area, Australasian Grebes seem to retain most of their breeding plumage colouration, and to date I have not seen non-breeding plumage, as illustrated in the field guides, in any mature birds.) It was interesting to see that a pair bond can be established before adult plumage is attained. On 10 November the two were building a nest, which had an egg in it on 17 November. One of the adults was not seen after 27 November.

On 9 December, after an incubation period of approximately 21 days, the single parent had one chick. We watched the parent take the empty eggshell and drop it in the water several metres from the nest. Although such behaviour is well known (Fjeldså 2004), it was exciting to see it for the first time. The next day there were two chicks, and by 11 December they had left the nest with the parent. But tragedy struck, and by the following morning both chicks had disappeared, their fate unknown. Other birds present included Little Pied Cormorant *Microcarbo melanoleucos*, Dusky Moorhen, Australasian Swampheh *Porphyrio melanotus* and White-faced Heron *Egretta novaehollandiae*, but it is not known if any of these birds were involved with the chicks' disappearance. The parent Grebe was refurbishing the nest, and calling occasionally. No other Grebe was seen there, so the parent may have been calling because it had lost its chicks, in the same way that these birds call after their nest has been destroyed by flooding (Hubregtse 2018).

#### 2019

##### *Another loss*

On 24 January two Grebes were present, and one was on a nest. On 27 February only one



Fig. 4. Very low water level at Jock Marshall Reserve, 12 April 2019.



Fig. 5. Water partly replenished at Jock Marshall Reserve, 15 May 2019.

adult and one chick were seen, but by this time the water was drying up fast in the hot, dry weather (Fig. 4). By 10 March it was clear that the chick was not growing much, no doubt due to lack of food in the rapidly shrinking pool of water. On 13 March the adult was chasing its two-week-old chick away because it couldn't find enough food for both of them. The next day the adult had gone, and the abandoned chick disappeared soon afterwards.

##### *Success at last!*

By 15 May the depleted waterbody had been partly filled (Fig. 5), and only a couple of weeks later, on 31 May, one Grebe was present. After this date, no Grebes were seen there until 29 July, when two were present. They stayed, and were building a nest on 25 October. One was sitting on the nest on 3 November while the other one was adding more material to the nest platform.



Fig. 6. Waterbody in Jock Marshall Reserve after removal of much of the vegetation, 26 May 2020.

Twenty-three days later, on 26 November, the first chick had hatched, and an adult was bringing food to the nest at frequent intervals. On 5 December we saw one adult and one chick in the water, while the other adult stayed on the nest. On 7 December there were four chicks, three about the same size, and the fourth a little smaller.

#### 2020

Three of the young birds stayed until 12 February 2020, when the adults were seen chasing them away, and the fourth was not seen after 18 February. From this time until 30 March, two adults were present, but were not seen

subsequently. At some time between the end of March and mid May, an aquatic weed harvester was brought in to remove excess growth of bulrushes and other vegetation. Fig. 6 shows the waterbody with much vegetation removed. It will be interesting to see how long it will be before Grebes again take up residence in the area.

#### Conclusion

Watching Australasian Grebes has proved to be a continuing source of interest, and it has been fascinating and often exciting to see various aspects of their behaviour. Losses of chicks continued to be high, with only six of 12 surviving to eight weeks of age.

#### Acknowledgements

Thank you to Jurrie Hubregtse for helping with observations of the Grebes.

#### References

- Fjeldså J (2004) *The Grebes*. (Oxford University Press: Oxford, UK).  
Hubregtse V (2018) Some observations of Australasian Grebes *Tachybaptus novaehollandiae* on and near a flood-retarding basin in Clayton, Victoria, together with comments on the habitat. *The Victorian Naturalist* 135, 118–124.  
Marchant S and Higgins PJ (Eds) (1990) *Handbook of Australian, New Zealand and Antarctic Birds*, vol. 1. (Oxford University Press: Melbourne).

Virgil Hubregtse

6 Saniky Street,  
Notting Hill, Victoria 3168.

---

## If this is *Dacryopinax spathularia*, look what we've been missing!

#### Introduction

In November 2019 I became convenor of a Friends group for Bay Road Heathland Sanctuary, a reserve owned by Bayside City Council in Greater Melbourne. Since then I have been trying to improve my records of its biodiversity to share with wider communities.

On 2 March 2020 I discovered several rows of a tiny (15 mm high) fungus growing in crevices on two Tea-tree *Leptospermum* spp. logs in the Sanctuary. On that day the fruit-bodies were roughly petaloid with a mostly smooth, semi-translucent apricot-coloured pileus overlaid with opaque greyish patches, resembling a

diminutive *Cantharellus* (Fig. 1). I sent some rather poor quality photos to FNCV Fungi Group members Virgil Hubregtse and John Eichler and, not surprisingly, they were unable to identify it.

On 10 March I went back to collect a small sample. The fruit-bodies had dehydrated further and were now a rubbery orange-brown around the edges and pale yellow towards the centre with a pore-like texture (Fig. 2). Two days later I gave the dried sample to Virgil, and we watched the fruit-bodies rehydrate after a damp paper tissue was placed in their plastic container. Their colour returned to a uniform

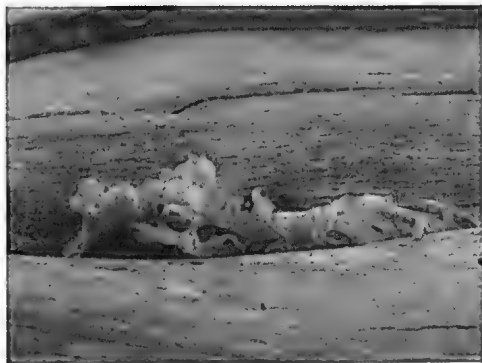


Fig. 1. Initial discovery at Bay Road Heathland Sanctuary, 2 March 2020.

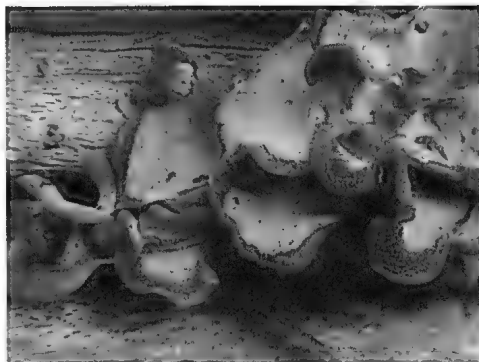


Fig. 2. Detail of the same fungus on 10 March 2020.

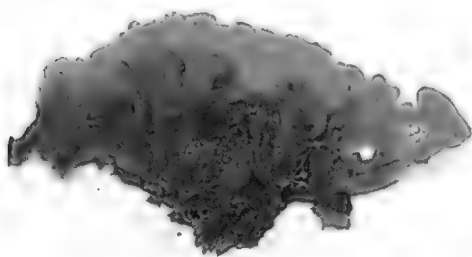


Fig. 3. Rehydrated sample, 12 March 2020.

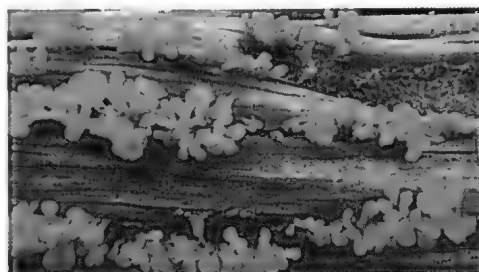


Fig. 4. Rehydrated fungus at Bay Road Heathland Sanctuary after three days of rain, 6 April 2020.

yellow or orange-brown, depending on their size and maturity (Fig. 3). I also emailed some photos to Dr Tom May, Senior Mycologist at the National Herbarium of Victoria.

Tom May suggested that it might be 'the jelly fungus *Dacryopinax spathularia* or something similar, as it is growing on wood' (pers. comm., 12 March 2020) and requested that I dry any specimens for the Herbarium (see Microscopic features, below).

On 3 April, after several days of heavy rain, John Eichler discovered that the original fruit-bodies had completely re-inflated and extended further along the two Tea-tree logs. I went back to take photos (Fig. 4). Now the fungus was a beautiful translucent bright lemon yellow with a uniformly smooth pileus and spatulate form, and was more readily identifiable as a jelly.

By 10 April it had dehydrated again, but a friend later reported that she had seen it in its hydrated form around mid April. I was starting to think that this process might continue

indefinitely, but by 30 April, after several days of heavy rain and colder temperatures, it had decomposed and there were no further sightings.

### Description of fruit-bodies

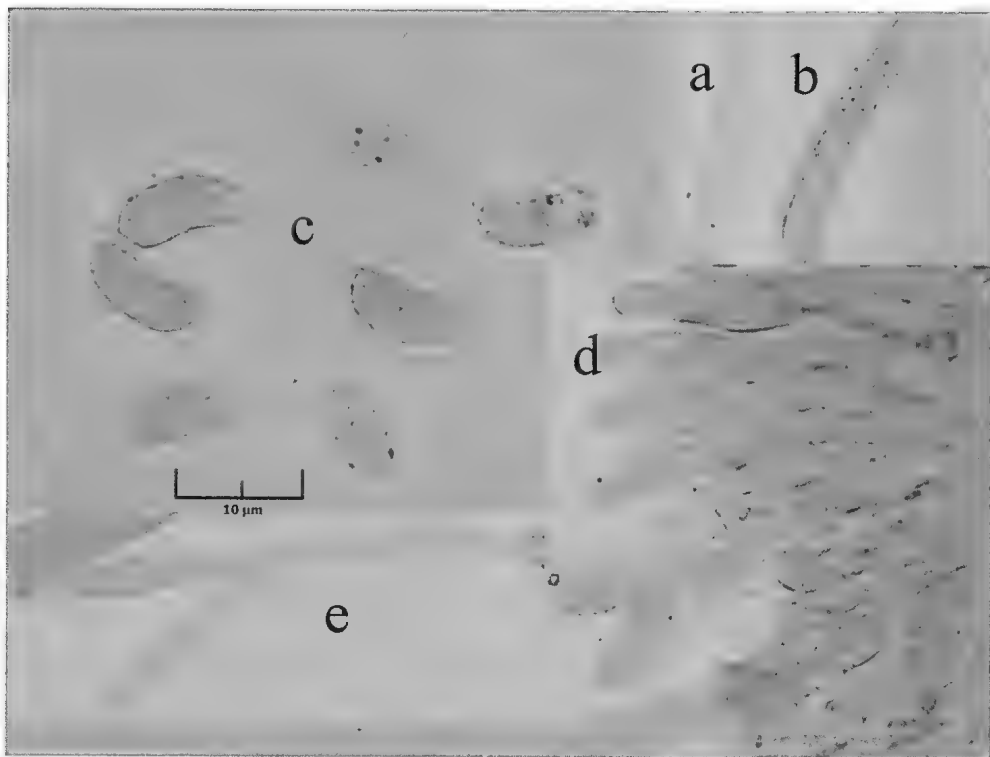
*Dacryopinax spathularia* (Schwein.) G.W. Martin

#### Macroscopic features

Basidiocarps caespitose, growing in lines; stipitate and pileate; to 20 mm high; covered in minute hairs; colour yellow to orange when fresh, drying first to orange-brown to reddish brown, and later, dull white (abhyemial surface) through to dull wine; pileus shape variable, lobed; petaloid, spatulate or palmate; consistency tough-gelatinous.

#### Microscopic features

Basidiospores slightly curved-cylindrical, smooth, with one thin septum when mature;  $9\text{--}11 \times 4\text{--}5.5\text{ }\mu\text{m}$ ; (mean length  $10.0 \pm 0.3\text{ }\mu\text{m}$ ; mean width  $4.6 \pm 0.3\text{ }\mu\text{m}$ ; mean Q [length to width ratio]  $2.21 \pm 0.17$ ;  $n=20$ ). Probasidia



**Fig. 5.** Microscopic features of fungus found at Bay Road Heathland Sanctuary, Sandringham, Victoria. a) smooth hypha; b) rough hypha; c) spores; d) immature basidia; e) basidium. Scale bar=10 μm. Stain used: solution of Congo Red and 5% ammonia. Composite photo Virgil Hubregtse.

cylindrical to subclavate, 28–36×3.5–5 μm, becoming bifurcate. Internal hyphae smooth or roughened, septate. Clamp connections absent (Fig. 5).

### Etymology

According to Gary Emberger ([www.messiah.edu](http://www.messiah.edu), 2008), the genus name *Dacryopinax* translates as ‘looks like tears’ (as in weeping) while *spathul* means ‘little spade or blade’ in reference to the flattened portion of the fruit-body. On iNaturalist Australia website (2020a), its common name is Fan-shaped Jelly-fungus, which aptly describes the curvature of individual fruit-bodies and the way they fan out and around each other.

### Collection examined

The fruit-bodies examined by Virgil Hubregtse had dried out and re-inflated, and were discarded because they were starting to break down.

The fruit-bodies did not occur in large numbers and had disappeared by the end of April. No new collections were made during April, but the area where the samples were found remains under surveillance for future collections.

### Discussion

The macroscopic and microscopic features of this fungus are generally consistent with the description of *D. spathularia* by McNabb (1965b), though the spore width is slightly larger.

The genus *Dacryopinax* currently comprises 22 living species ([www.mycobank.org](http://www.mycobank.org), 2.5.20). As McNabb (1965b: 60) indicated, *D. spathularia* is clearly not an easy fungus to identify: the growth form of *D. spathularia*, which possesses a lobed or morcheloid pileus and an essentially amphigenous hymenium does not readily fit within the generic circumscription, and if found isolated from typical spathulate basidiocarps, might not be associated with *Dacryopinax*.

He also notes that: ‘In *Dacryopinax spathularia*

the internal organisation approaches that of *Calocera*' (1965b: 59). In Australia, the fruit-bodies of *Calocera guepinoides* are highly variable in form and may be confused with emerging *D. spathularia*, but they are usually smaller, reaching a maximum height of 10 mm compared to 25 mm in the *Dacryopinax* species. There are also internal differences: *C. guepinoides* has slightly larger spores (11–15.5×4.5–5.5 µm compared to *D. spathularia* at 7–11.5×3.5–4.5 µm); mature spores may have up to three septa (one septum in *D. spathularia*); and, unlike *D. spathularia*, clamp connections are present in probasidia (McNabb 1965a, 1965b).

It can also be hard to distinguish species of *Calocera* from each other. For the past five years, I have been taking photos around Bay-side reserves of what I took to be *Calocera sinensis* growing on dead logs. Looking back over the photos, I can now see some emergent spathulate forms; they are subtly different from the club-like or 'sparingly forked' fruit-bodies of *C. sinensis* (Hubregtse 2019, Part 4: 107), and they may have been *C. guepinoides*.

## Records

During April 2020, I also set up a project to collect data for Bay Road Heathland Sanctuary on iNaturalist Australia (<https://inaturalist.ala.org.au/projects/bay-road-heathland-sanctuary>). John Eichler and I submitted our photos of the fungus to iNaturalist as *D. spathularia* and these records passed into the Atlas of Living Australia (ALA). However, at the time of writing, iNaturalist curators had not seconded our identifications. A review of the 29 Victorian *D. spathularia* submissions to iNaturalist on 29 July 2020 (2020a) demonstrates a similar identification problem, despite the fact that all ALA *Dacryopinax* records except one are for this species. On the same date, the Fungimap Australia project site on iNaturalist Australia (2020b) held 11 potential observations of it nationally.

While browsing the websites, I became curious about why there were so few records of this fungus in Victoria. In fact it is not recorded at all in the Victorian Biodiversity Atlas (DELWP 2020), which holds few records of any fungal species.

The Royal Botanic Gardens Melbourne's Interactive Catalogue of Australian Fungi has references

for *D. spathularia* dating back to 1882. Many of these are simply listings of earlier references. However, they do show that collectors and institutions were aware of *D. spathularia* in NSW and Queensland prior to this date, albeit under a variety of synonyms such as *Guepinia spathularia* Fr. (Cooke 1882) and *Guepinia fissa* Berk. (Massee 1892). Other recognised synonyms include *Merulius spathularius* Schwein. and *Dacryopinax fissus* (Berk.) G.W. Martin.

Writing in 1964, RFR McNabb thought that *D. spathularia* occurred throughout the world with the exception of Europe, but a current search on iNaturalist suggests that it occurs throughout Europe too. For Australia, on 3 May 2020, the ALA distribution map showed 174 records across all states, with the majority occurring along the eastern seaboard of NSW and Queensland as far north as Cape York Peninsula. The ALA holds many records of it in Oceanic islands and New Zealand, dating back to 1848.

Although the genus *Dacryopinax* is more commonly distributed throughout the tropics and subtropics, the ALA has four records of *D. spathularia* in Tasmania from the years 1994–95. On 3 May 2020, eight sites were recorded in Victoria, dating from 2015. Of the 12 observations, eight were from 2020 and they all occurred between March and June. These were in the areas of Mansfield (Mt Samaria SP), Belgrave (Sherbrooke Forest), Strathbogie (Mt Wombat Flora and Fauna Reserve), Ballarat, Cranbourne, Bruthen, Sandringham (Bay Road Heathland Sanctuary) and Burnley. There appears to be no easy explanation or pattern for the locations of the sightings. Given the older records in Tasmania and New Zealand, recent sightings in Victoria cannot simply be attributed to southern creep as an effect of global warming. Located just over one kilometre from the coast, Bay Road Heathland Sanctuary's vegetation is mostly classed as EV6 Sand Heathland with some Heathy Woodland. Cranbourne's remnant vegetation comprises Heathy Woodland, Grassy Woodland and Swamp Scrub, while Sherbrooke Forest is classified as Wet Sclerophyll Forest and is dominated by tall stands of Mountain Ash *Eucalyptus regnans*. The fungus appears to be tough and opportunistic, and has even been recorded growing on

polyester rugs (Wikipedia 2020) and treated wood (Emberger 2008). One possibility for Victoria's lack of records may simply be human oversight.

### Wetter conditions in 2020

Another reason may be Victoria's relative dryness. *Dacryopinax spathularia* appears to survive in a wide range of temperatures (there was a temperature variation of 20 degrees in the three days prior to John Eichler's photographic record), but it needs moist conditions for fruit-bodies to thrive. In the first four months of 2020 our rainfall was around 400 mm—equal to that for the whole of 2019. The rising number of Victorian records for 2020 may bear this out.

### Uses for *Dacryopinax spathularia*

Why should we pay particular attention to this aesthetically pleasing but globally common saprophytic fungus? The Indonesian forestry industry has been concerned about its association with brown rot (Suprapti 2010), but, internationally, current interest in *D. spathularia* lies elsewhere.

For a start, its edibility is well established. According to Wikipedia (2020), *D. spathularia* is used in China in a vegetarian dish called Buddha's delight, and is known as 'sweet osmanthus ear', a reference to its similarity in appearance to Osmanthus flowers. It is also eaten in Malaysia, Japan, India and Cameroon (IMD Natural Solutions GmbH 2017). In recent years the pharmaceutical industry has discovered *D. spathularia*. A 2019 study in India by Kumar *et al.* (see p. 696) notes that *D. spathularia* and *Schizophyllum commune* have:

been used traditionally for the treatment of various diseases and disorders such as antiviral, antitumour, antibacterial, and immunomodulating, anti-inflammatory, anti-diabetic, hepatoprotective activities (Mitko *et al.*, 2008; Adebayo *et al.*, 2012). Kumar *et al.* (2018) have ... found that both the macrofungi contain potent mycochemicals like tannins, saponins, alkaloids, flavonoids-phenolics etc. in significant quantities.

Their experiments demonstrated that mycochemicals found in these fungi effectively neutralised five human pathogenic bacteria—*Pseudomonas aeruginosa*, *Staphylococcus aureus*, *Proteus mirabilis*, *Bacillus subtilis* and *Salmonella typhi*—associated with typhoid, urinary tract infection, pulmonary tract infection,

pneumonia, and staphylococcal scalded skin syndrome (SSSS).

In 2012, five chemists working in Dortmund, Germany, formed IMD Natural Solutions GmbH and filed their first USA patent application for the use of long-chain glycolipids as a 'natural' antimicrobial preservative (Justia Patents 2012). Some of their studies into the long-term safety of *D. spathularia* glycolipids for human consumption were published in *Food and Chemical Toxicity* journal (Bitzer *et al.* 2019). Through fermentation, filtration and precipitation techniques, these compounds were initially extracted from a variety of fungi in the family Dacrymycetaceae before focus shifted to a sub-tropical strain of *D. spathularia*. In 2018 the USA Food and Drug Administration gave qualified approval to plans for using long-chain glycolipids from *D. spathularia* as a preservative in non-alcoholic beverages (FDA 2018). Other potential uses are in cosmetics, homeware and medical products. The company now trades as Lanxess and their *D. spathularia*-based invention is being commercially processed as a powder known as Nagardo™ (see [www.nagardo.com](http://www.nagardo.com)). It preserves by destroying the cell membranes of microbes responsible for spoilage, including yeasts, moulds and bacteria.

What a pity we haven't been paying more attention to that obscure little fungus on our doorstep!

### Acknowledgements

Thank you to Virgil Hubregtse for her microscopic analysis and images, to Dr Tom May for reviewing my photos and to John Eichler for his observations.

### References

- Atlas of Living Australia (2020) *Dacryopinax spathularia* <<https://bie.ala.org.au/species/https://id.biodiversity.org.au/name/apni/181615>> [accessed 3 May 2020].
- Bitzer J, Henkel T, Nikiforov AI, Rihner MO, Verspeek-Rip CM, Birol U and van den Wijngaard M (2019) Genetic toxicity studies of glycolipids from *Dacryopinax spathularia*. *Food and Chemical Toxicology* 123, 162–168. <<https://www.sciencedirect.com/science/journal/02786915>> [accessed 1 May 2020].
- Cooke MC (1882) Australian Fungi. *Grevillea* 11, 34. <<http://www.cybertruffle.org.uk/cyberliber/59649/0021/index.htm>> [accessed 29 July 2020].
- (DELWP) Department of Environment, Land, Water and Planning (2020), Victorian Biodiversity Atlas. <<https://www.environment.vic.gov.au/biodiversity/victorian-biodiversity-atlas>> [accessed 29 July 2020].
- Emberger G (2008) *Dacryopinax spathularia* <[www.messiah.edu](http://www.messiah.edu)> [accessed 1 May 2020].
- Hubregtse J (2019) *Fungi in Australia*, Rev. 2.2. E-published by the Field Naturalists Club of Victoria Inc., Blackburn, Victoria, Australia. <<http://www.fncv.org.au/fungi-in-australia>> [accessed 1 May 2020].

- IMD Natural Solutions GmbH (2017) Safety evaluation dossier supporting a generally recognised as safe (GRAS) conclusion for the use of long-chain glycolipids from *Dacryopinax spathularia* in non-alcoholic beverages, p. 18. In GRAS Notice (GRN) No. 74 (2017) <<https://www.fda.gov/Food/IngredientsPackagingLabeling/GRAS/NoticeInventory/default.htm>> [accessed 2 May 2020].
- iNaturalist Australia (2020a) Fan-shaped Jelly Fungus. <[https://inaturalist.ala.org.au/observations?place\\_id=6744&taxon\\_id=143313](https://inaturalist.ala.org.au/observations?place_id=6744&taxon_id=143313)> [accessed 29 July 2020].
- iNaturalist Australia (2020b) Fungimap Australia project. <<https://inaturalist.ala.org.au/projects/fungimap-australia>> [accessed 29 July 2020].
- Justia Patents (6 June 2012) Long chain glycolipids useful to avoid perishing or microbial contamination of materials. <<https://patents.justia.com/patent/20140178444>> [accessed 1 May 2020].
- Kumar A, Kumar M, Ali S, Lal SB and Sinha MP (2019) Antipathogenic efficacy of Indian edible macrofungi *Dacryopinax spathularia* (Schwein) and *Schizophyllum commune* (Fries) against some human pathogenic bacteria. *JETIR* 6, 695–704.
- Massee G (1892) Notes on Exotic Fungi in the Royal Herbarium, Kew. *Grevillea*, 21, 6. <<http://www.cybertruffle.org.uk/cyberliber/59649/0021/index.htm>> [accessed 29 July 2020].
- McNabb RFR (1965a) Taxonomic studies in the Dacrymycetaceae II. *Calocera* (Fries). *New Zealand Journal of Botany* 3, 31–58. <<https://doi.org/10.1080/0028825X.1965.10428712>> [accessed 25 June 2020].
- McNabb RFR (1965b) Taxonomic studies in the Dacrymycetaceae III. *Dacryopinax* Martin. *New Zealand Journal of Botany* 3, 59–72. <<https://doi.org/10.1080/0028825X.1965.10432062>> [accessed 28 April 2020].
- Royal Botanic Gardens Melbourne (2020) *Dacryopinax spathularia*. <<https://data.rbmg.vic.gov.au/cat/fungicatalogue/name/6739>> [accessed 1 June 2020].
- Supratti S (2010) Decay resistance of 84 Indonesian wood species against fungi. *Journal of Tropical Forest Science* 22, 81–87. <<https://www.jstor.org/stable/23616693?seq=1>> [accessed 2 May 2020].
- USA Food and Drug Administration (FDA) (2018) FDA Agency-Response-Letter-GRAS-Notice-No-GRN-000740. <<https://wayback.archive-it.org/7993/20180726143015/https://www.fda.gov/downloads/Food/IngredientsPackagingLabeling/GRAS/NoticeInventory/UCM610582.pdf>> [accessed 3 May 2020].
- Wikipedia contributors (2020) *Dacryopinax spathularia*. In *Wikipedia, The Free Encyclopedia*. <[https://en.wikipedia/wiki/Dacryopinax\\_spathularia](https://en.wikipedia/wiki/Dacryopinax_spathularia)> [accessed 2 May 2020].

**Sue Forster**

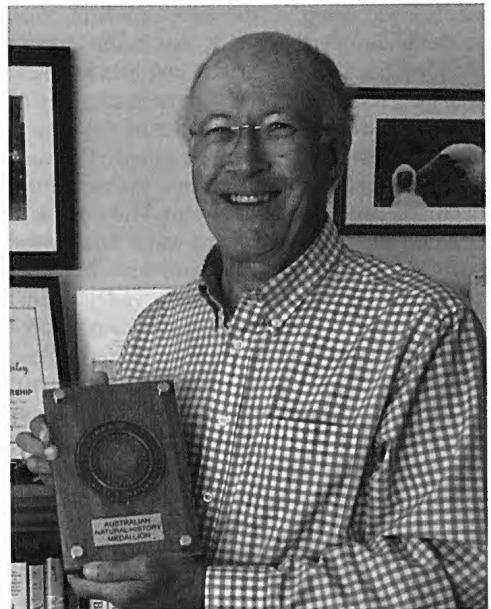
Field Naturalists Club of Victoria,  
PO Box 13, Blackburn,  
Victoria 3130.

## 2020 Australian Natural History Medallion: Craig Morley

Craig Morley has been awarded the Field Naturalists Club of Victoria's 2020 Australian Natural History Medallion for his contribution to ornithology, conservation and education. He was nominated by the Geelong Field Naturalists Club Inc.

Craig has demonstrated a strong commitment to ornithology, conservation and the education of others for more than forty years. His highly developed knowledge of the birds of the Geelong Region and beyond has been refined by decades of study, experience in the field and interaction with the wider ornithological community.

From a very young age, he was fascinated by nature, especially birds—a wonderful, obvious and exciting part of the world around us. To start with, they build nests, lay eggs in these nests and fly! Craig's projects in primary school included the Red Wattlebird—a regular visitor to his garden at home. He remembers, with joy and satisfaction, his first thornbill ID—a Striated Thornbill feeding amongst foliage in woodland



Craig Morley. Photo supplied.

in western Victoria. He has especially fond and vivid memories of receiving a copy of *What Bird is that?*—a gift for his twelfth birthday from his maternal grandparents. This came barely a year after his father's sudden death—the father who, in the few short years they had together, nurtured in Craig a life-long fascination with nature and learning.

Craig joined the Geelong Field Naturalists Club (GFNC) whilst completing a degree in Science and Education, majoring in Zoology with a sub-major in Chemistry. Within a very short time he had also joined the Royal Australasian Ornithologists Union (RAOU, now BirdLife Australia) and World Wildlife Fund (WWF). To this day, he maintains a strong and close association with all three. In 2019, Craig was awarded Life Membership of the Geelong Field Naturalists Club for his outstanding service and contributions to the Club.

As a prolific contributor to each of the two *Atlases of Australian Birds* and, more recently, to eBird Australia, his personal observations have allowed the study of movements, population changes and the emergence of new bird species at particular localities in the Geelong region. Since the advent of eBird in Australia and the collation of records in Local Government Areas (LGAs) Craig, at the time of writing, has submitted more than 12 000 lists in the Greater Geelong LGA and almost 18 000 lists for Australia. By example, Craig has inspired many to add their efforts and observations to various bird surveys and databases to ensure the availability of reliable data. In conservation battles, data-sets are knowledge—and knowledge is strength and power. In line with this theme he has participated, on a long-term basis, in programs such as the biannual wader counts on the Bellarine Peninsula (continuously since their inception in 1981) and the western lakes, and in regular surveys of Swift Parrots, bitterns, Latham's Snipe and Hooded Plovers. Craig has also assisted in the organisation and planning of many of these survey programs. On one such survey at Hospital Swamp, Connewarre, with John Newman in February 2002, he saw and then documented, in a major article in *Geelong Naturalist*, only the third record of Red-necked Phalarope for the Geelong region. Currently he is working with others to co-ordinate re-

search into colonially breeding ibis and spoon-bills, using remote pilotless aircraft surveys, at Reedy Lake in the lower Barwon wetlands. He also worked with Peter Menkhorst to help review plumage variation in Pied Currawongs in southern and south-western Victoria, leading to a review of the taxonomy, distribution and conservation status of subspecies of Pied Currawong in the region. This valuable and important information has been reported in *Australian Field Ornithology* and incorporated into the forthcoming edition of the *Action Plan for Australian Birds* along with insights to assist with the review of other species (in the latter).

From 1992–1994, Craig intensively studied a breeding pair of Australian Hobbies and has published a detailed report on the diet, prey partitioning and hunting behaviour of these birds in *Australian Field Ornithology*. Currently, he is working to publish a report on an exceptional 2017 Spotted Harrier breeding event in southern Victoria, when incubation commenced in early May and three juveniles successfully fledged in July.

From April 2005, Craig has been the Bellarine Peninsula Orange-bellied Parrot Regional Group Coordinator, a role which has seen him regularly promote awareness of the recovery effort for this critically endangered species with numerous presentations to conservation and natural history groups, schools and TAFE colleges. Over this time he has organised, led and participated in three surveys each year for this species and its close relative, the Blue-winged Parrot, across the Bellarine Peninsula. He has spent many additional hours in the field learning more about the Orange-bellied Parrot on the Bellarine Peninsula and beyond. Craig considers it a huge thrill and honour to be a member of its National Recovery Team.

Craig has contributed his expert knowledge to many conservation programs and issues. His extensive knowledge of birds has allowed him to make many significant contributions to conservation campaigns. As Minute Secretary and Communications Coordinator of a GFNC sub-committee, led by John Newman, Craig worked closely with many people in the successful campaign to preserve the de-commissioned evaporative Moolap Saltworks for international migratory and Australian endemic shorebirds and

present this site as an international standard wetland centre. The GFNC was pleased to encourage other like-minded local, national and international groups to become involved in the long campaign to protect these saltworks from development. A critically important part of this campaign was GFNC's ability to present a reliable and robust data-set, collected continuously at the site since 1981 on behalf of BirdLife Australia. This clearly shows that three species—Sharp-tailed Sandpiper, Red-necked Stint and Curlew Sandpiper—consistently occurred there at >1% of the East Asia-Australasian Flyway Population (the last critically endangered in the Flyway) and so invoked Federal Environment Protection and Biodiversity Conservation Legislation for protection of the site! The Victorian Minister for the Environment announced in August 2019 that the site would be protected for its environmental value, but there is much still to be done.

Craig is currently the GFNC representative on the Corangamite Catchment Management Authority Lower Barwon Wetlands Community Consultation Committee, a position he has held since 2012. He was the GFNC representative on the Eastern Park and Geelong Botanic Gardens Master Plan committee 1994–1999 for the duration of its tenure.

By 2008, the *Geelong Bird Report* (GBR) had evolved from an annual record of interesting observations into a more substantial publication. Craig took on the role of editor in 2009 and greatly expanded the amount of information in each annual edition until 2012. Under Craig's editorship, from 2013–2016, the format of the GBR changed to present, for the first time, a series of maps displaying seasonal distribution patterns for the vast majority of bird species of the Geelong region. Detailed comments on each species were provided along with graphs of seasonal reporting rates. Craig is grateful that he could work on this edition with Richard Alcorn, who listened to his dreams and desires and helped create the resulting publication, which is offered free as a searchable PDF document (downloadable from the GFNC website at <https://www.gfnc.org.au/about-us/publications>). Craig was also thrilled to organise a very successful print run, which sold out. The *Geelong Bird Report 2013–2016* has received acclaim from ornithologists across Australia and beyond.

Craig has led countless excursions, sharing his knowledge and encouraging others to learn more about birds, their habitat and interaction with the environment. For many years he has led and been recorder for the annual Challenge Bird Count through the Brisbane Ranges and You Yangs as well as, on numerous occasions, being recorder for the Bellarine Peninsula route. He has made many presentations about birds to GFNC meetings and to many other local community groups, including schools. As a former school teacher, he is particularly skilled at teaching and enthusing young people about local birds and the environment in general. In 2011, in his role as *Geelong Bird Report* editor, Craig produced a *Checklist of the Birds of the Geelong Region* for the fiftieth anniversary of the Geelong Field Naturalists Club. This has assisted people to identify and record their own bird observations.

Craig understands and well appreciates the value of consistent and repeat surveys to give a robust set of data on a site. He has now completed well over 1000 surveys in Eastern Park, an urban parkland on the edge of the city of Geelong, with more than 150 species recorded and more than 50 species breeding or attempting to breed in the 40-year period. This project began as an idea in December 1979 when Craig, as a young teacher, was looking for a project to engage students in the last days of the school year. With the support of a senior colleague, his plan to survey the birdlife of local urban parklands, as part of the first *Atlas of Australian Birds* in 1979, morphed into a 40-year survey. The story of the first 37 years of these surveys has been told in *Geelong Naturalist* and the eBird website: <https://ebird.org/australia/news/37-years-of-counting-building-a-long-term-picture>

Numerous articles have been published in *Geelong Naturalist* detailing aspects of Geelong's natural history, including at least seven on the birdlife of Eastern Park.

Since 2015 Craig's extensive and comprehensive knowledge, especially of the birds of the Geelong region, has made him a valuable member of eBird Australia's team as a reviewer of records for the State of Victoria.

Since 2010 he has organised and coordinated monthly excursions of the GFNC Bird Group, more recently with Lynne Clarke. Craig has

willingly and capably led many of these excursions. As convener of the GFNC Bird Group since 2013, he has hosted group meetings, inviting and convening many interesting and diverse presenters on a vast array of bird-related topics for its members and friends.

Craig is also fascinated by natural history more broadly, and in November 2010 he happened upon moths of the Family Geometridae at Breamlea, Victoria. This turned out to be a very exciting find: they were of the species *Scopula megalocentra* and this was the first time since 1904 that this moth had been recorded.

Craig Morley is honoured to join other Geelong Field Naturalists Club members who are previous recipients of the Australian Natural History Medallion: Roy Wheeler (1965), Jack Wheeler (1977), Trevor Pescott (1983), Marilyn Hewish (2013) and Margaret MacDonald (2015).

Unfortunately, due to Covid-19 restrictions in Melbourne, it was not possible for the medallion

presentation to be organised in the usual way with a reception hosted by the Field Naturalists Club of Victoria (FNCV). Therefore, a combined Zoom meeting of the Geelong Field Naturalist Club (GFNC) and the FNCV was arranged to coincide with the scheduled GFNC meeting on Tuesday, 1 December 2020. Invited guests also attended the presentation and Nick Williams, representing the Royal Society of Victoria, gave the citation. The medallion was then presented to Craig by GFNC Secretary Graham Possingham. After the presentation Craig thanked and acknowledged many people who had guided and influenced his naturalist journey. He then gave a fascinating talk, titled 'Australian Hobbies breeding in an urban parkland: some insights'.

**Maxwell Campbell**

President, Field Naturalists Club of Victoria,  
PO Box 13, Blackburn,  
Victoria 3130.

## Australian Natural History Medallion Trust Fund

During 2020, donations to the ANHM Trust Fund were gratefully received from the following:

	\$		\$
Alice Springs FNC Inc	100.00	Julia Davis	10.00
Sue Forster	50.00	Lesley Perkins	500.00
John Poppins	70.00	Rob Wallis	7.50

If you would like to contribute to this fund, which supports the Australian Natural History Medallion, donations should be sent to: The Treasurer, Field Naturalists Club of Victoria, PO Box 13, Blackburn, Victoria 3130. Cheques should be made payable to the 'Australian Natural History Medallion Trust Fund'.

The medallion is awarded annually to a person who is considered to have made the most significant contribution to the understanding of Australian natural history.

**Maxwell Campbell**

Secretary, ANHM Committee,  
Field Naturalists Club of Victoria,  
PO Box 13, Blackburn,  
Victoria 3130.

Museum Victoria



75505

JRNL  
N45-47